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The Macmillan Science Series

# Science for Tomorrow's World

*Teachers' Annotated Edition*

# SCIENCE FOR TOMORROW'S WORLD, BOOK 1

## YOUR TEACHERS' ANNOTATED EDITION PROVIDES:

- *A Teachers' Guide, bound into the back of the textbook*

  **The Content and Process of Science Education** (see guide pages 7 to 22)—This overview of science education in today's elementary schools explains the philosophy behind THE MACMILLAN SCIENCE SERIES, with emphasis on the *structure of subject matter* in the science curriculum and the *conceptual framework* of the series.

  **How Children Acquire Science Knowledge: A Developmental Approach** (see guide pages 23 to 31)—Here is a practical discussion of the relationship between the teaching of science and the development of logical thought processes.

  **Some Problems of Method in Teaching Science** (see guide pages 32 to 61)—This part of the guide covers such important topics as providing for individual differences and using community resources.

  **Overviews, Tests, and Directories** (see guide page 62)—Here are overviews for each unit in the book plus the table of contents of each book in the SCIENCE FOR TOMORROW'S WORLD, BOOKS 1-6, series to appraise you of the place of your book in the series structure. This section also includes tests for each unit in the textbook and directories of publishers, film and filmstrip sources, and suppliers of source materials.

- *The Pupils' Textbook, with teaching suggestions printed beside the text pages and with annotations printed right on the text pages*

  **Fully developed lesson plans | Background information | Additional activities and demonstrations | Readings for the pupils and the teacher | Answers to the questions in the textbook | Checklist of science materials**

# SOME OF THE SPECIAL FEATURES YOU'LL FIND IN BOOK 1:

## *Units organized to teach the Key Concepts of science*

SCIENCE FOR TOMORROW'S WORLD, BOOK 1, is built on the 10 Key Concepts of science that are described on pages 12–18 in the Teachers' Guide. Throughout the text, specific concepts are developed that, in turn, lead the pupils toward deeper understanding of the Key Concepts. For example, these are the concepts developed in Unit 3:

**The Key Concepts**

All objects in the universe and all particles of matter are constantly in motion; man has discovered and stated the laws governing their motion.

The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.

**Some of the Specific Concepts**

**1.** It takes a force to move an object (pages 46-48).

**2.** There are different kinds of forces—magnetic, human, gravitational (pages 47-53).

**3.** Machines can be used in applying force to move objects or to keep them from moving (pages 47-49).

**4.** Magnets do not have to touch objects to exert force on them. Magnetic forces act through certain substances (pages 51-53).

**5.** Only certain objects are attracted by magnetic forces (pages 50 and 54).

**6.** Like poles of magnets repel, and unlike poles attract (pages 54 and 55).

**7.** Magnets can be used to magnetize objects such as a steel needle (pages 58, 59, and 61).

## *Lessons, activities, observations, and illustrations that take full advantage of the child's natural curiosity*

The authors of SCIENCE FOR TOMORROW'S WORLD, BOOK 1, believe that the natural curiosity of the child is a powerful motivating tool in acquiring science knowledge. Throughout the textbook, they involve the pupils in open-ended science activities, always making sure that the *purpose* behind each of these varied experiences is clear.

Notice, on the following pages, how the pupils learn to investigate the world around them in many different ways:

- On pages 7, 11, 14, 15, 23, and 75 the pupils learn by *feeling*.
- On pages 9, 10, 17, 22, 25, 39, 51, 61, and 87-89 the pupils learn by *watching*.
- On pages 19, 20, 28, 29, 64, 65, and 68-70 the pupils learn by *studying pictures*.
- On pages 92, 93, 95, and 96 the pupils learn by *hearing*.
- On pages 32 and 33 the pupils learn by *tasting*.
- On page 70 the pupils learn by *counting*.
- On pages 16, 34-38, 86, and 105-111 the pupils learn by *reading*.

**For more special features, turn to the inside back cover.**

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# THE MACMILLAN SCIENCE SERIES

TEACHERS' ANNOTATED EDITION


**SENIOR RESPONSIBILITY FOR THE SERIES**

J. DARRELL BARNARD
SCIENCE EDUCATION

CELIA STENDLER
CHILD DEVELOPMENT AND ELEMENTARY EDUCATION

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**UNDER THE EDITORSHIP OF**

SIDNEY SELTZER



SCIENCE FOR TOMORROW'S WORLD: 1, 2, 3, 4, 5, 6
SCIENCE: A SEARCH FOR EVIDENCE 7
SCIENCE: A WAY TO SOLVE PROBLEMS 8
SCIENCE: A KEY TO THE FUTURE 9


Texts, Teachers' Annotated Editions, and other Complementary and Supplementary Teaching Materials

The TEACHERS' ANNOTATED EDITION consists of

- Teaching Suggestions
- Annotated text pages
- Teachers' Guide

THE MACMILLAN SCIENCE SERIES

# Science for Tomorrow's World 1

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TEACHERS' ANNOTATED EDITION

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*Teachers' Annotated Edition with Teaching Suggestions and Teaching Guide*

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### ABOUT THE TEACHING SUGGESTIONS

Teaching Suggestions, for each page in the pupil's textbook, are found on the outside of the page. The Teaching Suggestions include lesson plans, background material, the answers to the questions posed in the pupil's pages, additional activities, and bibliographies of books and films. The suggestions apply directly to the material on the pupil's pages and provide a ready reference for the teacher as he or she uses the textbook in class. Many pages have space on them for teachers to write in their own comments. A Materials Checklist is included in each book, containing ample space for teachers to add materials for experiments and demonstrations of their own.

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PROFESSIONAL BOOKS FOR TEACHERS

Blough, Glenn O., *It's Time for Better Elementary School Science*. NSTA, 1958. 48 pp. Of special interest to administrators and supervisors. Theory for science curriculum construction.

Brandwein, Paul F., Fletcher G. Watson, and Paul E. Blackwood. *A Book of Methods*. New York: Harcourt, Brace, 1958. 568 pp. An excellent sourcebook.

Deason, Hilary J., *Science Booklist for Children,* American Association for Advancement of Science, and NSF, Washington, D.C., 1960. 138 pp.

Hone, Elizabeth B., and Alexander Joseph, Edward Victor, and Paul F. Brandwein. *A Sourcebook for Elementary Science*. New York: Harcourt, Brace & World, 1962, 552 pp. An excellent sourcebook.

Stendler, Celia B., *Teaching in the Elementary School*. New York: Harcourt, Brace, 1958.

Victor, Edward, *Science for Elementary School,* New York: Macmillan, 1965.

Woodburn, John H. and Ellsworth S. Obourn, *Teaching and the Pursuit of Science,* New York: Macmillan, 1965.


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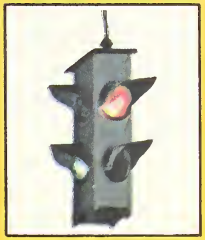

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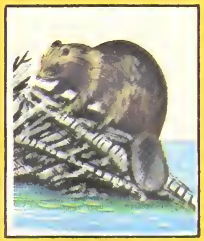


*California Journal of Elementary Education,* Vol. 21, No. 2, November 1952. 63 pp. Special issue on science for every child and every teacher; characteristics of a good program, equipment, and materials.

*Leadership for Science in the Elementary Schools.* California Association for Supervision and Curriculum Development, 1960. 88 pp. A handbook for teachers, administrators, consultants, and supervisors.

*Looking Ahead in Science.* California State Department of Education, 1960. 88 pp. Report of the Production Seminar and Conferences on the Improvement of Science Education in the Elementary School Purposes, appropriate experiences and content, equipment and materials, scheduling, evaluation, pre- and in-service education.

*Safety Through Elementary Science.* Washington, D.C.: National Education Association, 1949.

*Theory Into Action.* NSTA, 1964. 48 pp. Discusses science curriculum development based on conceptual schemes.

*UNESCO: Source Book for Science Teaching.* New York: UNESCO, 1959. This volume has been revised, expanded, and reprinted in many editions.

# 1 THE WEATHER CHANGES

KEY CONCEPTS

**Key Concept 1.** Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

**Key Concept 5.** The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.

**Key Concept 6.** There is a basic tendency toward stability or equilibrium in the universe; thus, energy and matter may be transformed, but the sum total of matter and energy is conserved.

**Key Concept 9.** The scientist has developed measures of space, time, and matter so that he can communicate explanations that are reproducible and make predictions about events in the natural environment.

**CONCEPTS:**

1. Weather conditions change as the temperature of the air changes.
2. The weather changes constantly.
3. The weather affects what we do and what we wear.

## Warm and Sunny

# Warm and Cloudy

*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



4. Different kinds of weather occur at different times of the year.
5. The sun warms the earth.
6. Rain is one kind of weather.
7. Snow is one kind of weather.
8. Water, as matter, changes state with changes in temperature.
9. When water evaporates, it goes into the air.
10. Water evaporates faster when the air is moving.
11. When warm air touches a cold object, water comes out of the air.
12. Cool air falls.
13. Warm air rises.
14. Clouds are formed when the water vapor in the air becomes drops of water.
15. When the air gets very cold, the water vapor in the air turns into snowflakes.
16. All snowflakes have six sides.
17. Every snowflake is different.
18. Wind is moving air.
19. Wind moves things.

**PROCESSES:**

- Observing—Visual and tactile —Pages 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25.
- Experimenting—7, 10, 11, 14, 15, 17, 22, 23.
- Comparing—9, 10, 11, 14, 15, 18, 19, 21, 22, 23, 25.
- Inferring—5, 7, 8, 10, 11, 12, 13, 20, 21, 25.
- Measuring—9, 21, 22, 24, 25.

# Cold and Sunny

TEACHING SUGGESTIONS

● **LESSON:** How many ways can the weather change?

**Learnings to Be Developed:** Weather conditions change as the temperature of the air changes.

**Developing the Lesson:** Start a discussion by having the children look at the pictures on these two pages.

- *What season do you think it is?*
- *What things in the picture help you to know?*
- *What are the children wearing?*
- *Why do they wear such clothing?*
- *Look at page 3. How has the weather changed?*
- *Look again at the pictures on pages viii and 1. How are those pictures different from the pictures on pages 2 and 3?*
- *How are things you do in the summer different from things you do in the winter?*
- *What happens to plants when winter comes?* (If children answer, "Plants die," ask, "Does this happen to all plants?")
- *What happens to animals when winter comes?*
- *What happens to the ground when winter comes?*

- *Why do we do different things in different weather?*
- *What kinds of weather have you learned about?*

**Follow-Up:** On the chalkboard, write, "A Cloudy Day," "A Rainy Day," "A Snowy Day," "A Sunny Day." Have each child select one type of day that he would like to illustrate. Organize the illustrations into a bulletin board display. Have each child describe what he has drawn. Have the children tell how the pictures differ.

○ **ADDITIONAL ACTIVITIES:** If it is winter, have the children bring in evergreen plants or branches and a small animal such as a rabbit or a turtle. Have the children look at each and try to tell how wild animals are able to live outdoors during the winter months. Note, for instance, the rabbit's furry coat.

- *Where does the rabbit find its food during the winter?*
- *How do the living things change during the summer?*

Have the children bring in some hard-packed earth.

- *How does the earth change during summer and winter?*

TEACHING SUGGESTIONS

**LESSON:** What do you do when it rains?

**Learnings to Be Developed:** Rain is one kind of weather.

**Developing the Lesson:** Start a discussion by looking at the pictures.

- *What kind of weather do you see?*
- *What happens when it rains?*
- *Which boy is dressed for rainy weather?*

Have one child read the question on page 5 and let the other children answer it.

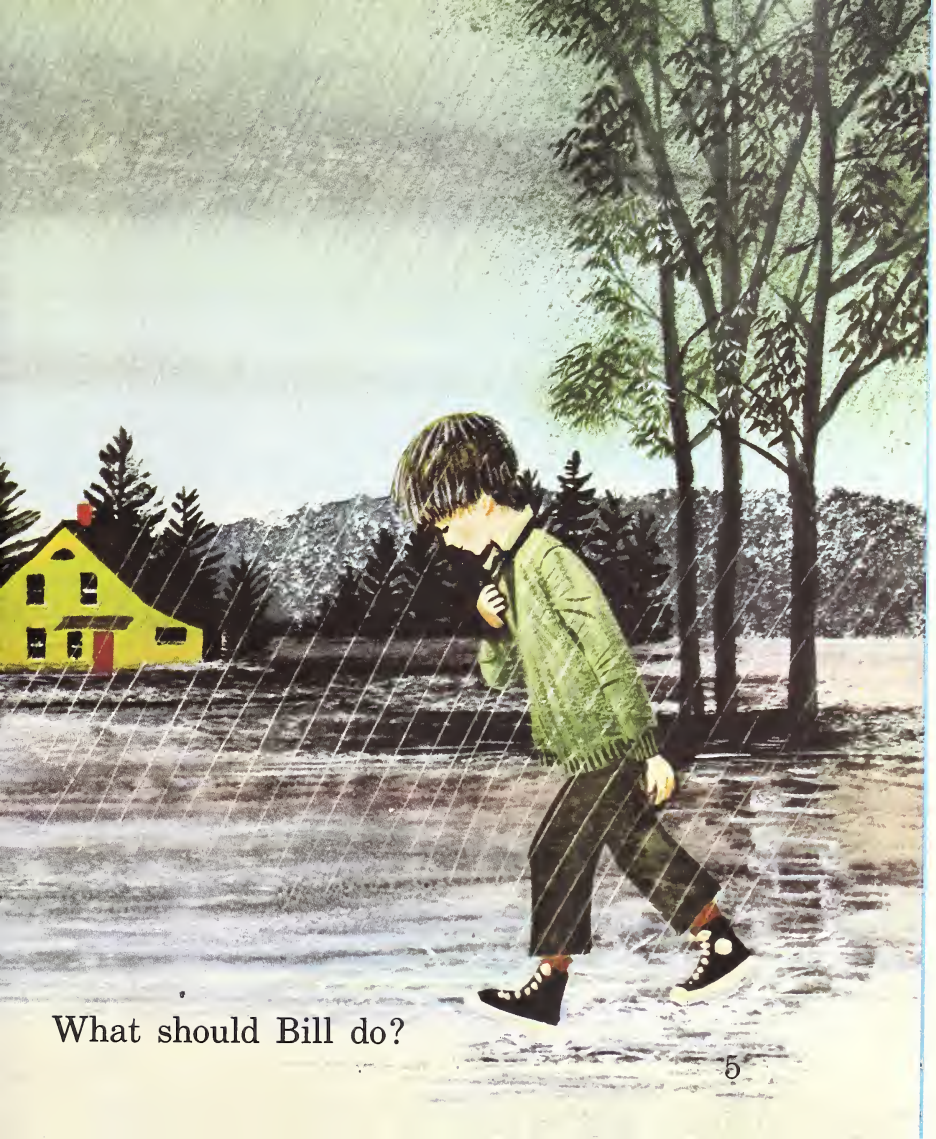
Why should children wear rubber boots when it rains? You will need the following:

Old shoe
Rubber boot
Pan of water (large enough to hold both the shoe and the boot)

Show the shoe and the rubber boot to the class.

- *How are they different?*
- *What is each made of?*
- *What will happen to them when you put them into water?*

# Rain



What should Bill do?



Put the shoe and the boot into the water. Allow time for a thorough soaking; then remove them from the water. Have the children feel the insides of each.

- *What do you feel?*
- *Why should you wear rubber boots when there is rain?*
- *What else can you do to keep dry when there is rain?* (Wear a raincoat.)
- *What other kinds of things will keep you dry?* (An umbrella.)

**Follow-Up:**

*Do you wear different clothes for rain and for snow? For cold weather and for sunny weather? For warm weather and for cloudy weather?*

Have the children look through magazines for pictures of various kinds of weather, and have them make a weather scrapbook.

Compare the different kinds of clothing worn for different kinds of weather.

- *How does each kind of clothing protect you from the weather?*

*Bring in some water-repellent materials. Show how these materials repel water*

# Snow

TEACHING SUGGESTIONS

**LESSON:** What happens when it snows?

**Learnings to Be Developed:** Snow is one kind of weather.

**Developing the Lesson:** Start a discussion based on the kind of weather seen in the picture on page 6.

- *Where are the children? Why?*
- *If the children wanted to go outside, what would they have to do?*
- *What is hanging from the tree?* (Bird house.)
- *What is the bird house for?*
- *Where does snow come from?*
- *What is snow made of?*
- *How can you find out what snow is made of?*
- *At what time of year is there snow?*
- *Must the weather be cold for snow to fall?*
- *Can the weather be hot when it snows?*
- *Where does it snow?* (Only in cold places.)

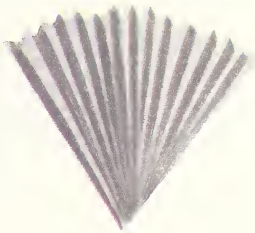
**Follow-Up:**

- *What happens to outdoor plants and to animals in cold weather?*

*Ask why a fan makes them feel cool. (It speeds evaporation of perspiration from skin.) Use stiff paper to make the fan shown.*

# Air

Make this.



Do this.

What do you feel?

Air is all around you.

**ADDITIONAL ACTIVITIES:**

If it is winter and there is snow, bring some snow to class. Have the children feel it. Have them watch it melt. Ask the children how they might keep it from melting.

**LESSON:** What is all around us?

**Learnings to Be Developed:** Air is all around us.

**Developing the Lesson:** Tell the children the following riddle:

- *It is right in front of your nose, but you cannot see it. What is it?* (Air.)

Distribute paper to the class and tell the children they will use the paper to find the answer. Supervise the folding of the fans.

- *What have you made?*
- *What do you do with a fan?*
- *What other kinds of fans do you know about?* (Electric fans.)
- *What do they do?*

Have the children imitate the activity of the child in the picture.

**Follow-Up:**

- *Where do you find air?*
- *How do you know air is there?*
- *How does the fan show that air is all around us?*

**LESSON:** Where does the water go?

**Background:** This lesson introduces the concept that air takes up water. Warm air takes up water faster than cold air, and moving air takes up water faster than still air. Call the children's attention to a jar of paste or some water paints that have dried. Ask what caused the paste or paint to dry. This lesson will tell the children what happened.

**Learnings to Be Developed:** When water evaporates, it goes into the air.

**Developing the Lesson:** Start the lesson with a discussion. Have the children look first at the picture on page 8.

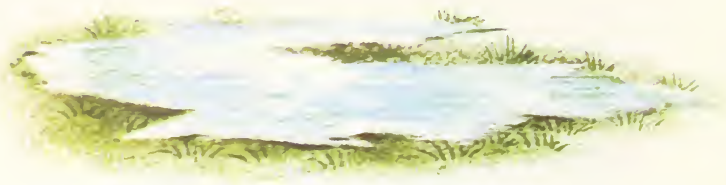
*Where does the water go?*

List on the chalkboard the suggestions that the children make.

*What happens to the water puddle and to the water in the clothes on the line?*

You may wish to introduce the word *evaporation* at this point. If you do, have the children tell what things besides water can evaporate.

# Where Does the Water Go?



The water goes into the air.

Do this.

What is different?
Where did the water go?



- *Look at the calendar dates. What do they show?*
- *What is happening in the pictures?* (Water is evaporating.)
- *Did all the water evaporate? How long did it take for the water to go into the air?* (Repeat this activity in your own classroom. Be sure the children select a warm and sunny spot.)

**Follow-Up:** Ask the children to think of places where there is water: in lakes, streams, oceans, soil, and food. Explain that moisture evaporates from all of these, all the time. Even when we perspire, moisture evaporates.

**ADDITIONAL ACTIVITIES:**

Wash a dish in cold water and let it stand for a few minutes. Wash another dish in hot water and let it stand for a few minutes. See which dish dries faster.

There is moisture in all living things. Have the children press a leaf between two pieces of paper, and have them note that the paper becomes damp.

Place a carrot or slice of apple on a dish. Note, in about a day or two, how the carrot or apple begins to shrivel. Put the carrot or apple in water. Note how it takes up water and swells.

TEACHING SUGGESTIONS

● **LESSON:** Which dries faster?

**Learnings to Be Developed:** Water evaporates faster when the air is moving.

**Developing the Lesson:** Have the children repeat the activity shown on page 10. Have them use a wet eraser.

- *Which streak will dry more quickly?* (Use the word *evaporate* if it has already been introduced. Repeated usage of the word will help to reinforce its meaning.)
- *Why does one streak dry more quickly?*
- *What does the fanning do?*
- *What does fanning do to the air?*
- *What do we call air that is moving?* (Wind.)

**Follow-Up:** Have a child use an eraser to wet an area on the chalkboard. Ask him to blow on the wet area.

- *What happens when you blow on the wet part of the board?*
- *Why is blowing on the board like fanning the board?* (Point out that both are ways to move air.)

# Which Dries Faster?

Do this.

And this.

# Which Dries Faster?

Do this.

And this.

**LESSON:** Which dries faster?

**Learnings to Be Developed:** Water evaporates faster when it is warm.

**Developing the Lesson:** Have the children look at the pictures.

- *Where is the air moving?*
- *How do you know?*
- *What does the moving air do to the cloth?*
- *Which of the two cloths will dry faster?*
- *Where does the water from the cloths go?*

**Follow-Up:**

- *What is the best kind of day to hang clothes out to dry?* (A sunny, breezy day.)
- *How do you dry clothes in your house?*
- *Do you use moving air to dry the clothes?*

**ADDITIONAL ACTIVITIES:**

- Have the children soak two cloths with water. Hang one of the cloths near an open, sunny window. Hang the other cloth where no direct sunlight or heat can get to it. Have the children inspect the two cloths after about an hour to see whether one has dried more than the other.

**LESSON:** When does water come out of the air?

**Learnings to Be Developed:** When warm air touches a cold object, water comes out of the air.

**Developing the Lesson:** Have the children read page 12 and suggest their own answers to the question at the bottom of the page.

- *Was it warm or cold when Tom went outside?*
- *How does the picture show this?*
- *Was it warm or cold when he came inside?*
- *What happened when the warm air touched Tom's glasses?* (The glasses became covered with drops of water.)
- *Where did the drops of water come from?*

# Water Comes Out of the Air

Tom is playing.
It is cold.

Tom goes in.
It is warm.

Look at Tom's glasses.
What happened?

The air is warm.
The window is cold.
What happens?

The water is cold.
The air is warm.
What happens?

Use similar questions to discuss page 13.

Repeat the activity that shows the girl putting ice cubes into a pitcher of water.

- *What do you see on the outside of the pitcher?*
- *What can you feel on the outside of the pitcher?*
- *What does the liquid on the outside of the pitcher taste like?*
- *What do you think the liquid is?*
- *Where do you think it came from?*

**Follow-Up:** Place a pitcher of warm water in the refrigerator.

- *What happens to the outside of the pitcher after about fifteen minutes?*
- *Why do you think this happened?*

TEACHING SUGGESTIONS

● **LESSON:** What can you find out about cold air and warm air?

**Learnings to Be Developed:**

Cool air falls.

Warm air rises.

**Background:** Air is made up of atoms and molecules that are always in motion. Moving atoms and molecules possess *energy*. The faster the motion of the molecules, the higher the temperature of the air. The slower the motion, the lower the temperature.

Since the molecules in cold air are moving slowly, there are more of them than there would be in the same amount of hot air. The cooler the air is, the heavier it is. Cool air thus tends to fall. Warm air rises.

# Cold Air

Do this.

And this.

And this.

Where is the air colder?

# Warm Air

Have your mother do this.

Caution child to wait until pyrex pitcher is safe to handle before going on to next step.

Do this.

Empty pyrex pitcher of warm water.

And this.

Warm air rises from empty pyrex pitcher.

What do you feel?



**Developing the Lesson:** Discuss pages 14 and 15 with the class. If possible, duplicate the demonstrations. Lead the children to the conclusions that cool air falls and warm air rises.

**Follow-Up:** Have the children feel for cool air under the crack of a door. Have them feel for warm air over a heater that is turned on. To make the concept more graphic, tie streamers to a radiator that is giving off heat.

- *In what direction do the streamers go?*
- *What does this tell you about the air coming from the radiator?*

TEACHING SUGGESTIONS

**LESSON:** How does a cloud form?

**Learnings to Be Developed:** Clouds are formed when the water vapor in the air becomes drops of water.

**Developing the Lesson:** Review pages 12 through 15.

- *In what direction does warm air go?*
- *In what direction does cold air go?*
- *What happens when warm air touches cold air?*
- *What happens when you breathe out on a cold day?* (A small cloud forms.)

Have the children read page 16. The concept on this page can be made more concrete by doing the activity on page 17.

# Clouds

Cold air pushes warm air up.
The warm air goes up high.
Then the warm air gets cold.
Little drops of water come out.
The little drops make a cloud.

Have your mother do this.

For safety use a pyrex jar

Do this.

Do you see a cloud?

The drops are like rain.
The drops get bigger and bigger.
What will happen?



Water vapor will not change from a gas to a liquid unless it has something on which to condense. Water vapor in the air condenses on such things as pollen and dust particles.

**Follow-Up:**

- *What is a cloud made of?* (Water and dust.)
- *What happens when the water drops get bigger and bigger?* (Rain falls.)

**ADDITIONAL ACTIVITIES:**

Another valuable visual experience for the children will result from clapping an eraser filled with chalk dust above steam emerging from a boiling kettle of water.

TEACHING SUGGESTIONS

● **LESSON:** How do snowflakes form?

**Learnings to Be Developed:**

When the air gets very cold, the water vapor in the air turns into snowflakes.

All snowflakes have six sides.

Every snowflake is different.

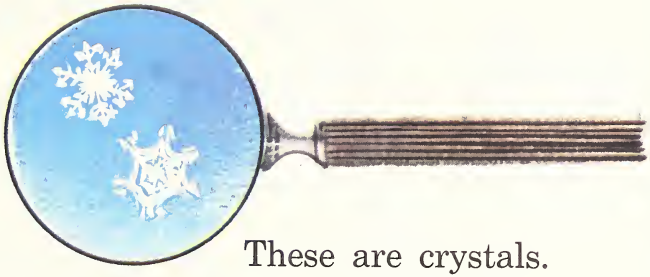
**Background:** When the water vapor in the air changes directly into solid, transparent ice crystals, snow is formed. This change occurs when air temperatures are below 32 degrees Fahrenheit. The shapes of crystals of snow always vary from one another, but their *basic* shape is always six-sided, or hexagonal. A snowflake appears to be white because of its many reflecting surfaces.

# Snowflakes

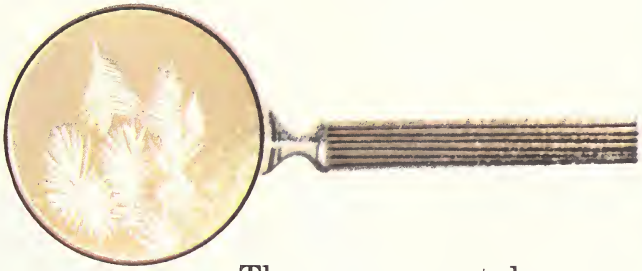
The air up high is very cold.
There is water in the air.
What will happen to the water?

How are the snowflakes alike?
How are they different?

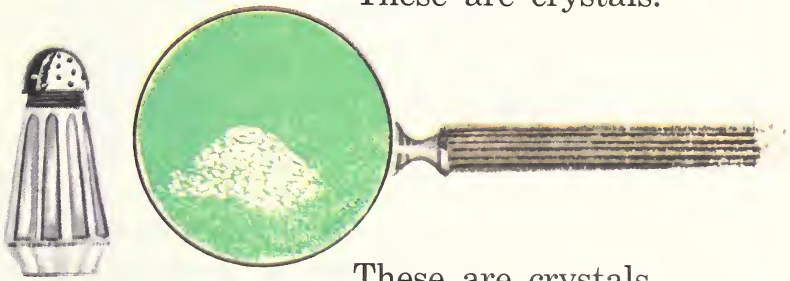
# Crystals



These are crystals.



These are crystals.



These are crystals.



**Developing the Lesson:** Look at the pictures on pages 18 and 19.

- *Have you ever watched your mother defrost the refrigerator?*
- *What was on the sides of the freezer?* (Ice.)
- *Where do you think the ice came from?* (Water in the air of the freezer. The water in the air changed into tiny pieces of ice, called *crystals*.)

Have the children use a magnifying glass to look at salt crystals. (Tell the class that salt is also made of crystals.)

- *Does a salt crystal look like a snowflake crystal?*
- *How are they alike?*
- *How are they different?*

If it is winter and there is snow, have the children use a magnifying glass to examine some snowflakes.

- *How does snow change when it is put in a warm place?*

**Follow-Up:** Have the children make paper snowflakes out of folded paper. This should help the children to see that snowflakes have regular shapes.

TEACHING SUGGESTIONS

**LESSON:** What is wind?

**Learnings to Be Developed:** Wind is moving air.

**Developing the Lesson:** Discuss the pictures on page 20.

- *Are the clothes and chimney smoke moving to the side in the top picture? Why not?*
- *Are the clothes and chimney smoke moving to the side in the bottom picture? Why?*

To help the children answer the last two questions on page 20, have them look at page 21

Discuss page 21 and have the children answer the questions there. If possible, go out to the schoolyard on a windy day and have the children repeat the activity shown on page 21.

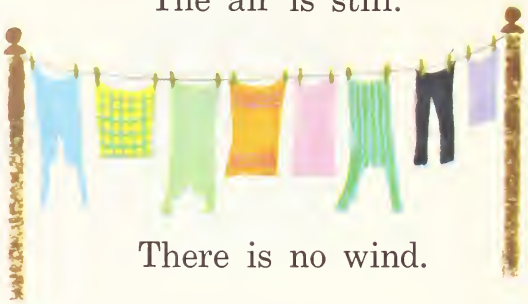
To further show that wind pushes, crumple up a piece of paper and put it on a desk or table. Select one child to be the "wind." Have the child push the paper across the table by blowing on it. He will show by his own action that the wind pushes.

**ADDITIONAL ACTIVITIES:**

Simulate a sailboat ride, using boats made of cork and sails made of paper. The children can be the "winds."

# Wind

The air is still.



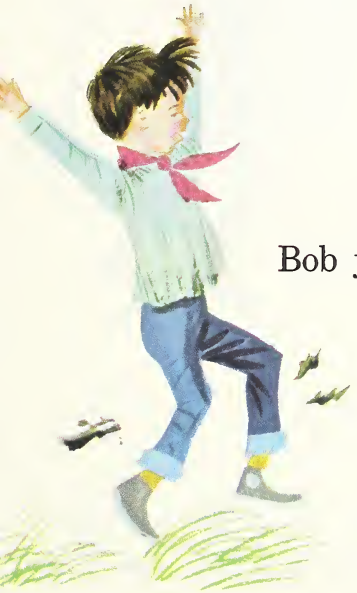
There is no wind.

Now the air is moving.

Wind is air that is moving.
Which way is the wind moving?
How can you tell?

# Wind Pushes

Bob jumps into the wind.



Bob jumps with the wind.

Which jump is bigger?
Can you tell why?



Have a child place a sheet of paper on his outstretched hand. Then have him turn rapidly in a circle, holding the palm of his hand at right angles to the floor.

- *What holds the paper against your hand?* (Moving air.)
- *What do you feel against the paper?*
- *What does the air do to the paper?*
- *Where did the air come from?* (It is there all the time; the child put it in motion.)

Here is another way to prove that air is all around you and that moving air can do things.

Tie a string to a piece of paper, about an inch from the edge so that the string won't tear out easily. Have a child hold the string and walk with the paper.

- *Does it go up in the air? Why?* (Because the air around the paper is set into motion.)

Have the same child run with the paper.

- *What happens?* (The paper rises higher and flutters vigorously.)
- *How does running help to lift the paper?* (Running helps because the paper is pushed harder against the air. If air is in motion, the air will push the paper without your running.)

## TEACHING SUGGESTIONS

● **LESSON:** What can we find out about the way wind pushes things?

**Learnings to Be Developed:**

Wind moves things.

Wind may blow from different directions.

**Developing the Lesson:** Discuss what the wind does.

- *What does the wind do?* (Blows against things, such as clothes on a line; turns things over, such as papers, cans; blows hats off and carries them down the street; blows dust.)
- *What is the boy doing in the picture at the top of page 22?*
- *What will happen if he pushes his paper airplane into the wind?*
- *Will the wind carry away the paper airplane?*

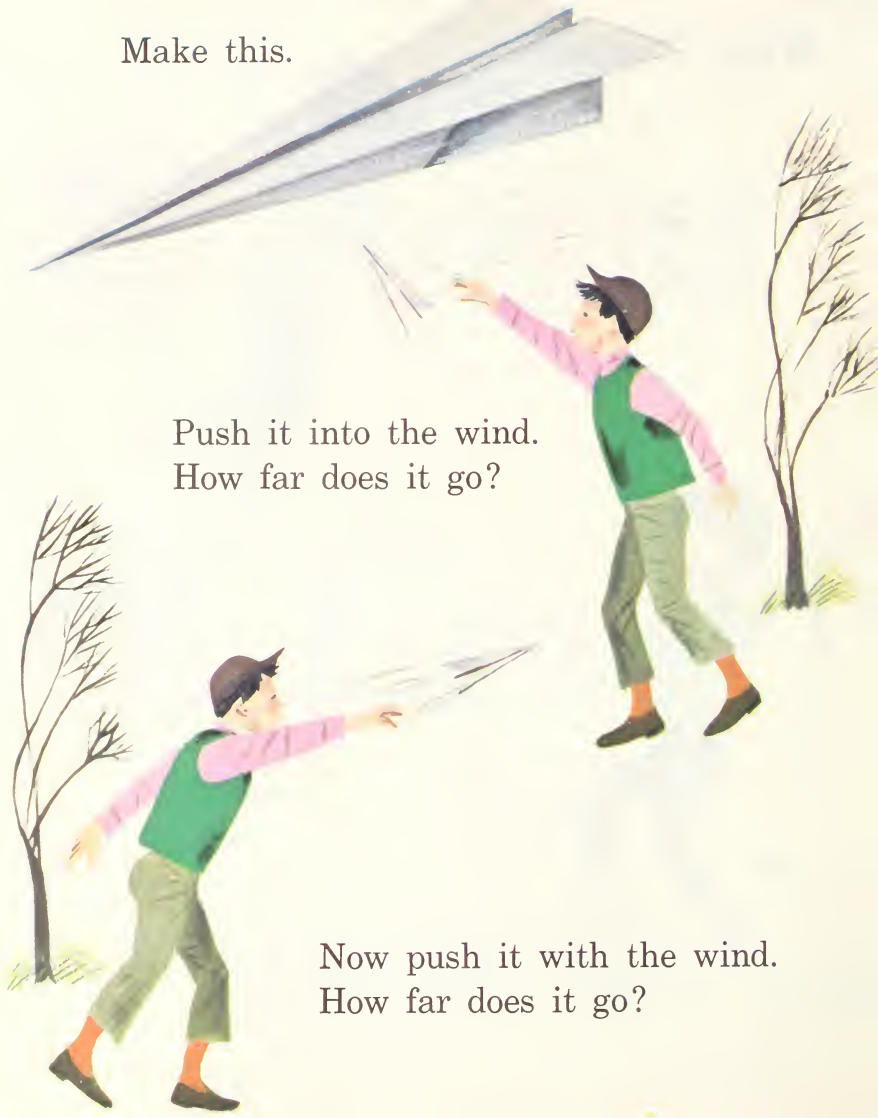
Have the children look at the bottom picture on page 22. Repeat the above questions, referring to this picture.

**Follow-Up:**

Have the children make some kites and sail them if possible.

Have the children make paper pinwheels.

Make this.

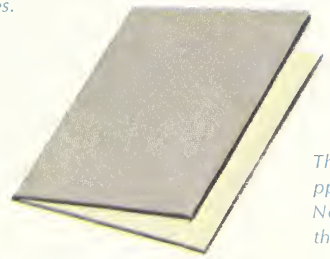


Push it into the wind.
How far does it go?

Now push it with the wind.
How far does it go?

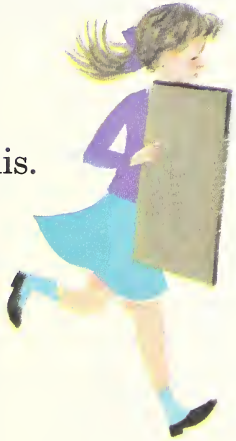
*2 or 3 different sizes and shapes.*

Get this.



*This activity and the ones on pp. 20-21 were inspired by Newton's suggestion that the force of the wind can be measured in terms of length of jump with and against the wind. Such activities provide a sensori-motor readiness for the concept that forces can be added and subtracted. See Unit 2, Book 2, for a continuation of concept development.*

Do this.



Now do this.

Do you feel the wind more?



Prepare two or three large pieces of cardboard, each about eighteen by twenty-four inches. Fold each cardboard in half, making it about eighteen by twelve inches. A carton from the grocery store will do if it is cut apart and folded. The cardboard pieces do not need to have these exact dimensions, provided the children can hold the pieces of cardboard comfortably.

Tell the children that page 23 shows something else they can try outdoors after school. Ask for several volunteers who will take the cardboard, try this activity, and report to the class what they find out. (This activity may be done by the class on the playground if the teacher prefers.)

The purpose of this activity is to show the difference between resistance of air to a large surface and to a smaller surface.

After several children have tried it, let them describe their experiences in their own words. Help them to generalize that it is harder to run when there is a big surface pushing against the air. It is easier to run when the surface is smaller (folded).

TEACHING SUGGESTIONS

**LESSON:** How can we tell how fast the wind moves?

**Learnings to Be Developed:** Instruments help to show the direction of the wind.

**Developing the Lesson:** Read page 24 with the children.

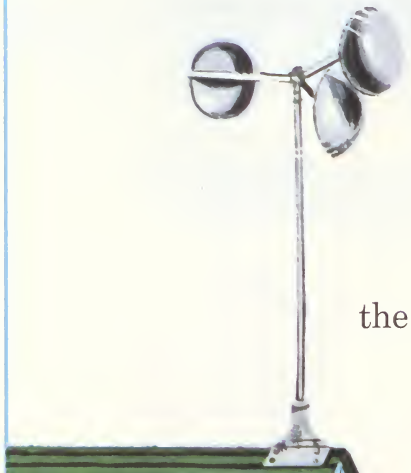
- *What do you think the instrument on top of the house does?* (It measures wind speed.)
- *What makes it move?* (The wind.)
- *What happens to the instrument when the wind blows very hard?* (It moves faster.)
- *What happens when the wind blows gently?*
- *Is there a strong wind in the picture on page 24? How can you tell?* (Tree is bent.)

Tell the children the name of the instrument on the house. (Anemometer.)

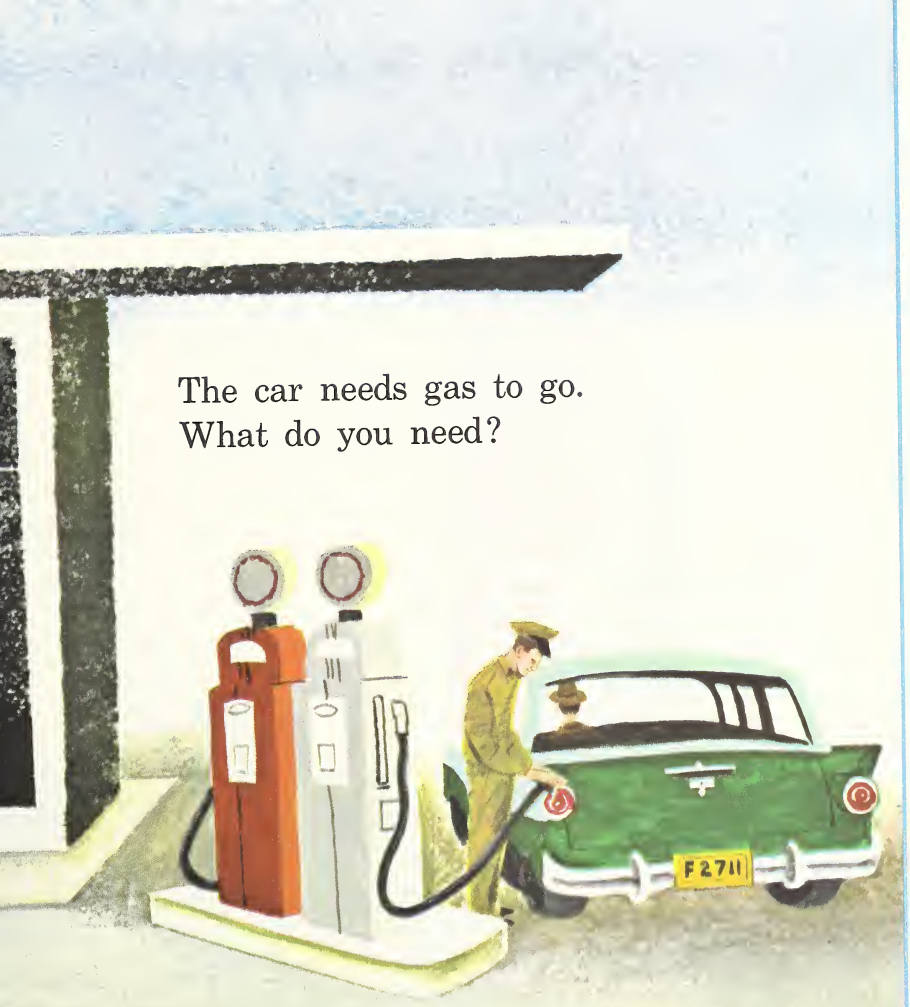
- *Why do you think scientists use instruments to measure the speed of the wind?* (Instruments help in making weather forecasts.)

Have the children listen to a weather forecast. Ask them to take note of the wind speed.

# How Fast Does the Wind Move?



This tells how fast the wind is moving.




*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



8. Different foods help supply different things for keeping well.
9. Some foods can be prepared very simply.
10. Microorganisms living within the body may cause illness.
11. Many diseases are caused by germs.
12. It is necessary to remain at home when you are ill.
13. Materials may be introduced into the body of animals to prevent illness caused by microorganisms.
14. Animals need shots to stay well.
15. Foods can be preserved by removing water.
16. Animals have various ways of keeping their bodies clean.
17. Different animals remove dirt from their bodies in different ways.
18. Animals have different skin coverings.

**PROCESSES:**

- Observing—Pages 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43. Microscopes are used to extend vision—pp. 34, 35.
- Experimenting—39, 42, 43.
- Comparing—26, 27, 28, 29, 35, 37, 38, 40, 41.
- Inferring—26, 27, 28, 29.
- Measuring—36.
- Classifying—30, 31.

TEACHING SUGGESTIONS

● **LESSON:** Why do you need a good breakfast and a good lunch?

**Learnings to Be Developed:** It is important that you have a good breakfast and a good lunch so that you get enough energy to keep well.

**Developing the Lesson:** Have children read and discuss page 28.

- *How does Mary feel?*
- *What is Mary doing?*
- *Is she having fun in school? Why not?*
- *Can Mary pay attention to her lessons? Why not?*

Refer to the comparisons the children made previously between themselves and cars.

- *How do you know when a car needs fuel?* (Gas gauge shows "Empty"; car won't move.)
- *How does Mary know she needs food?* (She feels tired, hungry.)
- *What should Mary do so that she will have time to eat breakfast?*

# You Need a Good Breakfast

Look at Mary.
She has no time for breakfast.

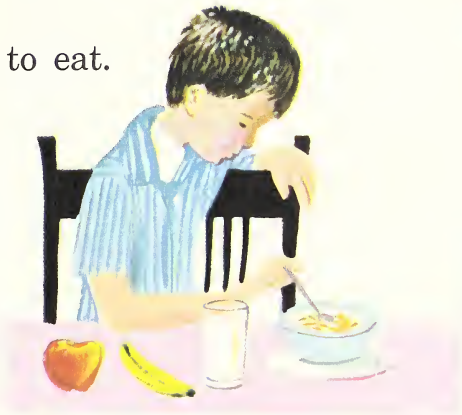
*Use the pictures on these two pages to teach that there is a physical basis for our behavior. Guide pupils in giving similar examples of physical cause and social effect.*

What happens to Mary?
Why?

*Ask pupils to relate experiences similar to those shown here.*

# You Need a Good Lunch

Look at Jack.
He does not want to eat.



What happens to Jack?
Why?

- *Do you eat a good breakfast every morning?*
- *What happens when you do not?*
- *How do you make sure you will have time for breakfast?*

Have the children read and discuss page 29. Follow the same type of questioning as was used for page 28.

- *Why do you think Jack does not want to eat?* (Now is a good time to discuss why children should not chew gum or eat candy just before a meal.)
- *Why do you think Jack is cross?*
- *What should Jack do?*
- *Does being hungry sometimes make you cross?*

**Follow-Up:** Cut out magazine pictures that show good breakfast and lunch foods. Arrange a display.

- *How can you find out what foods you need to keep well?* (This will provide you with a lead-in to the next lesson.)

TEACHING SUGGESTIONS

**LESSON:** Why do you need different foods?

**Learnings to Be Developed:** Different foods help supply different things for keeping well.

**Developing the Lesson:** Ask the children to try to name some foods that help them to grow and keep well.

- *Why should you eat different kinds of foods each day?*
- *Do you eat different foods each day?*

Have the children discuss their own favorite foods. Have children from different culture groups bring in foods that are served in their homes. How do these foods fit into the groups of foods shown on pages 30 and 31? Ask the children what foods they eat for breakfast. Write the names of the foods on the chalkboard. Then ask the children to name some foods that should *not* be eaten in place of mealtime foods. (Candy, cake, pie.)

- *How can you know which foods are good for you?* (Ask school nurse, doctor.)

# You Need Different Foods

These foods help you grow.

*Primarily protein.*

These foods help you run and play.

*Primarily carbohydrates and fats.*

These foods help you keep well.

*Primarily vitamins, minerals, and roughage.*

Can you choose a good breakfast?
Can you choose a good lunch?



*Work out some menus with the children. Stress variety as well as health values.*

**Follow-Up:**

- *Why do we have to eat different kinds of foods?* (Some foods provide energy; others help us grow and keep well.)
- *Can you choose good meals for breakfast, lunch, and dinner?*

Help the children become aware of the four groups of food. (Meat group, Milk group, Fruit-Vegetable group, Bread-Cereal group.) Have the children check to see whether or not they eat some foods from each group every day.

The teacher should be familiar with local food preferences. It would be helpful to have children from different culture groups tell about the foods served in their homes.

**ADDITIONAL ACTIVITIES:**

Have the children cut out pictures of foods and make up imaginary breakfasts, lunches, and dinners from the assortment.

Visit a local market to see a variety of vegetables, meats, and dairy products. Note how the perishable foods are stored and handled.

TEACHING SUGGESTIONS

● **LESSON:** How are some foods made?

**Learnings to Be Developed:** Some foods can be prepared very simply.

**Developing the Lesson:** Discuss various types of milk that are commerically available (Dry milk, skimmed milk, evaporated milk, buttermilk, bottled milk.) Bring in a sample of each.

- *How is dry milk different from bottled milk?*
- *How is skimmed milk different from regular milk?*
- *What are the differences among the other kinds of milk?*
- *What has the boy in the picture done to the dried milk?* (He has added water.)
- *Why do you think milk is prepared these different ways?*
- *What does regular milk have in it?*

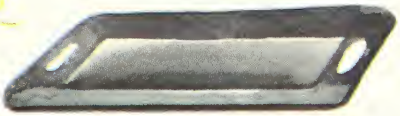
# Make Something to Drink

Get these.

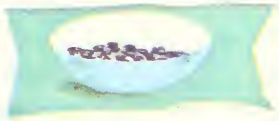
Do this.

# Make Something to Eat

Get these.



Do this.





Now look at page 33.

- *What will the grapes be called when they are dried?* (Raisins.)

**Follow-Up:**

- *Can water be taken out of milk?*
- *What happens to grapes when you leave them out to dry?*

**ADDITIONAL ACTIVITIES:**

You might like to make a Picture-Dictionary of Foods. Have each child take one letter of the alphabet, and then ask each child to write a simple sentence for a food whose name begins with that letter. Each child will contribute his page to the class dictionary.

TEACHING SUGGESTIONS

- **LESSON:** What are germs?

**Learnings to Be Developed:** Many diseases are caused by germs.

**Developing the Lesson:** Have the children read page 34.

- *Who is the man in the picture?* (A scientist.)
- *What is he using?*
- *Why does he use a microscope?* (It enlarges small things so they can be seen by the eye.)
- *What other things help to make small things seem bigger?* (Magnifying glass, telescope, binoculars, eyeglasses.)

If possible, have a few of these instruments available so that the children can get firsthand experience using them. Now have the children read page 35. Discuss various diseases they have had or know about. Explain that different diseases are caused by different germs. Have the children compare the pictures of germs on page 35.

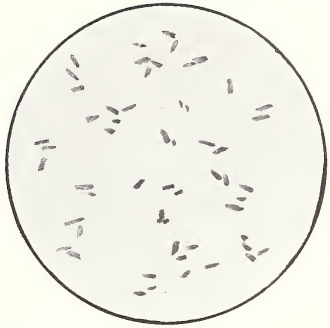
- *Do all of the germs in the pictures look alike?*
- *Do you think all of the germs cause the same disease?*

# Germs

Germs can make you sick.
Germs are very, very little.

This man can see germs.
What helps him see them?

The man sees germs that look like this.



These germs are different.

Germs can make people sick in different ways.



- *Where are germs found?* (Such places as in the air when people sneeze; on soiled hands.)
- *How can we stop germs from going from one person to another?* (By using a handkerchief when sneezing; by washing hands. Use a handkerchief to show the children how to cover the mouth and nose while sneezing.)

**Follow-Up:**

- *What can happen when germs go from one person to another person?*

**ADDITIONAL ACTIVITIES:**

You may want to suggest these books to the children.

Haynes, Olive V. *The True Book of Health*. Chicago: Children's Press, Inc., 1954.

Schloat, G. Warren. *Your Wonderful Teeth*. New York: Charles Scribner's Sons, 1954.

Scott, William R. *This Is the Water That Jack Drank*. New York: William R. Scott, Inc., 1950.

Have your students visit the library and look for elementary-level books on the subjects of health and disease. Some of the students can report to the class on their findings.

TEACHING SUGGESTIONS

● **LESSON:** What happens when germs make you sick?

**Learnings to Be Developed:** It is necessary to remain at home when you are ill.

**Developing the Lesson:** Have someone read page 36.

- *What are some things that happen to you when you get sick?* (Sore throat, headache, upset stomach, tiredness.)
- *What does your mother do when you feel sick?* (Sends the child to bed, takes his temperature, calls a doctor.)
- *What are some things the doctor does when he comes?* (Asks questions and makes an examination.)
- *Why should you stay in bed when you are sick?*
- *What are some things you can do if you must stay in bed?*

**Follow-Up:**

- *What should you do if you feel sick?*

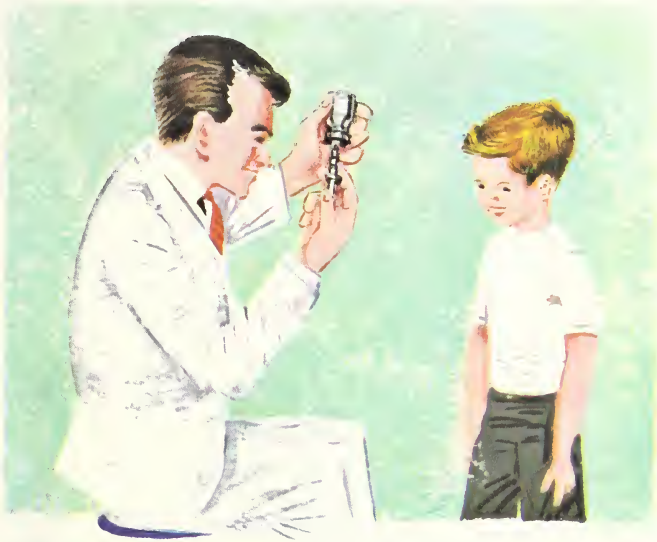
You can get germs
from other children.
Other children can
get germs from you.

You should stay home
when you are sick.

# Getting Shots

Have you seen the doctor do this?

He is getting ready to give the boy a shot.



Shots help to kill germs that might make you sick.



**LESSON:** Why do you get shots?

**Learnings to Be Developed:**

Shots help to prevent certain diseases.

A needle is used to inject serum into the body.

**Developing the Lesson:** Read page 37 with the children.

- *How do you think the boy in the picture feels?*

Most children are afraid of getting shots. They get a momentary glimpse of the needle but rarely do they get an opportunity to look at the needle, or talk about it in a non-threatening situation.

Too often children are misled by adults who say, "It doesn't hurt." It does hurt! Adults need to recognize this fact. But they should help children see that the hurt of the needle is momentary and not so bad as the illness that they may get if they do not have the shot.

Help children to understand that it is often their feelings of fear, rather than the pain itself, that upset them, and that talking about their feelings sometimes helps.

**Follow-Up:**

- *Why is it important to get shots?*
- *Do animals sometimes get shots?*

TEACHING SUGGESTIONS

● **LESSON:** Why do animals need shots?

**Learnings to Be Developed:** Animals need shots to stay well.

**Developing the Lesson:** Start a discussion about pets.

- *What are some of the things you must do to keep your pet healthy and happy?*
- *How do you know if your pet does not feel well?*
- *What would you do if you saw that your pet were sick?*

Now have children read page 38.

- *Do animals get shots for the same reasons that children do?* (Dogs, for example, need shots against rabies and distemper.)

**Follow-Up:**

- *How should you take care of animals to keep them healthy?*

Animals get shots too.

Shots help animals stay well.

The doctor uses a needle to give shots.

How does a needle work?
You can find out.

Get this.

Do this.

What happens when you squeeze?
What happens when you let go?



● **LESSON:** How does a needle work?

**Learnings to Be Developed:**

A needle can suck up serum because air has been pushed out of the tube.

Serum replaces the air in the tube.

The plunger forces the serum out of the tube.

**Developing the Lesson:** Obtain an old needle and syringe from the school nurse. If a needle and syringe are not available, use an eyedropper that has various levels marked off.

- *When a doctor wants to give you a shot, what does he do?* (He pulls out the handle of the syringe, and the air pressure forces the serum into the tube. If possible, demonstrate this.)

Have the children use a plastic squeeze bottle to show how a syringe works. Put the bottle under water and squeeze out the air. Note the air bubbles. When you stop squeezing the bottle, water is forced back into the bottle, taking the place of the expelled air.

**Follow-Up:**

- *What else works like a needle?* (Plastic squeeze bottle, fountain pen.)

TEACHING SUGGESTIONS

● **LESSON:** How do animals keep clean?

**Learnings to Be Developed:**

Different animals remove dirt from their bodies in different ways.

Animals have different skin coverings.

**Developing the Lesson:** Have the children look at the pictures of the animals.

- *What are the animals doing?* (Washing.)
- *How are the animals' body coverings different?* (Fur, feathers, tough skin.)
- *What are some other kinds of coverings that animals have?* (Shells, on turtles; scales, on fish.)

Dust bathing is common among certain animals. Dust bathing keeps fur or feathers free from accumulation of oils secreted by glands. Children may have observed this practice in birds. Some desert animals, such as the kangaroo rat also engage in dust bathing.

# Keeping Clean

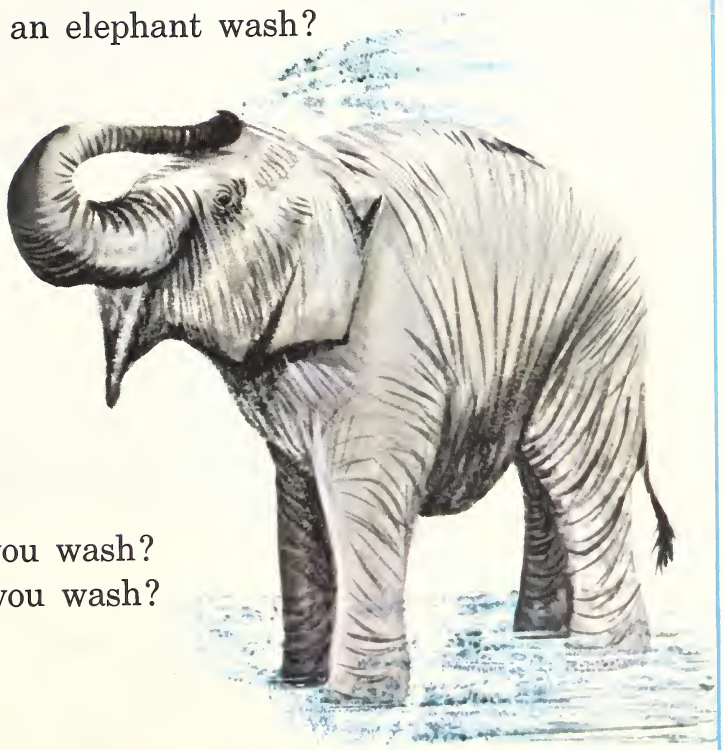
*Let your pupils compare the animals on these two pages. Point out the differences and the similarities among them. Use other pictures of animals to extend this activity.*

How does a cat wash?

How does a dog wash?

How does a bird wash?

How does an elephant wash?



How do you wash?
Why do you wash?

Have the children read the text and then have them describe the actions of each animal. (Lapping, splashing, showering, etc.)

- *Have you ever seen such animals washing in these ways?* (Have the children tell about experiences of watching animals wash.)
- *Why do people wash?* (To keep clean and to feel refreshed. Washing helps to kill germs.)
- *What other ways do animals wash themselves?* (Horses roll, chickens preen themselves with their bills.)

**Follow-Up:**

- *Do all animals wash in the same way?*
- *Do all animals have the same kind of body covering?*

**ADDITIONAL ACTIVITIES:**

Have the children make a chart on good grooming. Wherever possible, use pictures from magazines to depict the good-grooming rules selected by the class.

Write to a large pharmaceutical company, requesting a chart on good grooming.

TEACHING SUGGESTIONS

**LESSON:** How does washing help us to keep clean?

**Learnings to Be Developed:**

It is important to keep ourselves clean and neat.

Washing helps to protect us from germs.

Water helps the action of soap.

Soap helps to make things clean.

Warm water removes dirt better than cold water does.

Rubbing helps the action of soap and water.

**Developing the Lesson:** Have children read and answer questions on page 42. Point out ridges and valleys of skin as seen under magnifying glass. Have children note dirt between ridges.

You will need two basins of water, a bar of soap, two towels, and a magnifying glass. Have two children rub their hands on some desk tops. The hands of both children should be slightly soiled from this. Then have one of the children wash his hands with only water and a washcloth. Have the other child wash his hands with water, a washcloth, and soap. Compare the two children's hands under a magnifying glass. Which child's hands are cleaner?

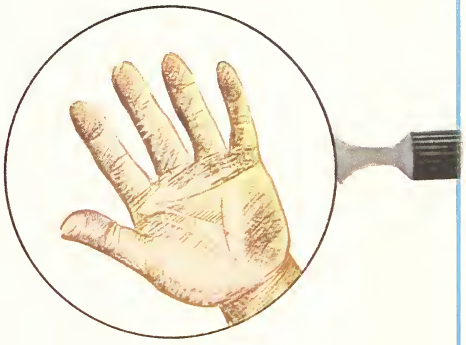
# Washing Helps Us Keep Clean

What do you see?

Will these help you wash?

Wash with water.

What do you see?



Now wash with these.

What do you see?

- *What does water do when you wash?* (It helps the action of soap; it rinses away soap and dirt.)
- *Why do we use soap when we wash?* (Soap helps to loosen dirt.)

**ADDITIONAL ACTIVITIES:**

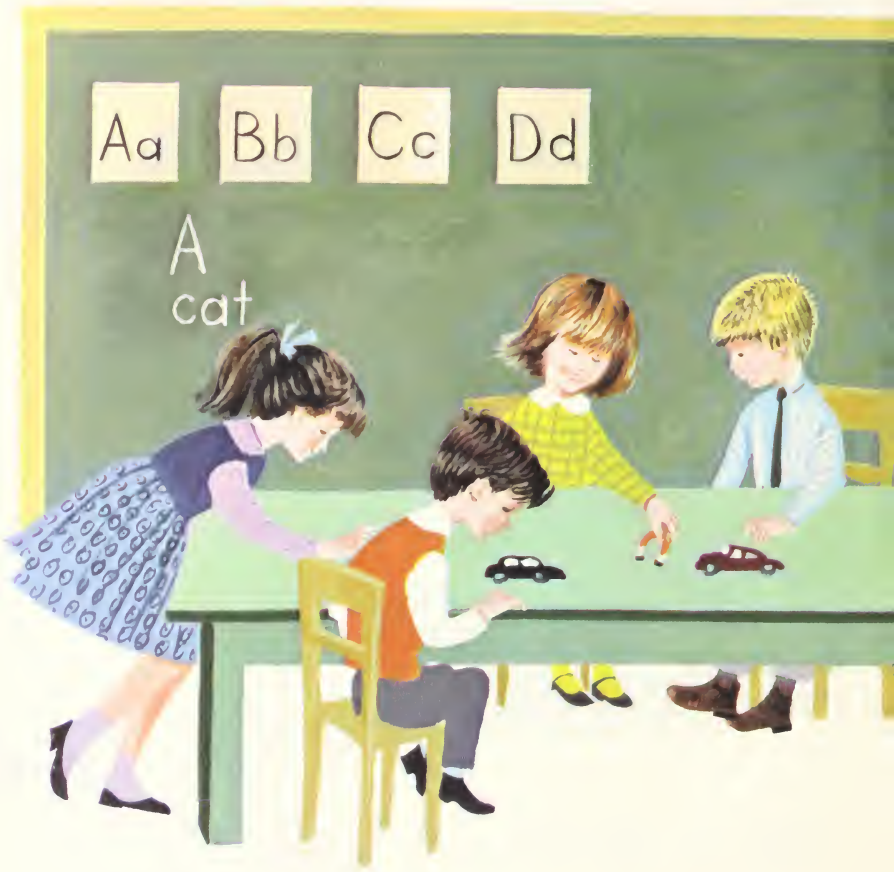
You will need a pitcher of warm water and a pitcher of cold water. Obtain two wash basins. Have a pail on hand to empty wash water if a drain is not available in the room. You will also need a piece of clean white cloth, such as part of an old sheet. Have the children soil the cloth by rubbing it over the floor or on their shoes.

Tell the children to find out if warm water is better than cold water to wash things clean. Have as many children as possible working in pairs. Cut the soiled cloth in two. Let one child wash one piece in a basin of cold water while another child washes a piece in warm water. The cloths are hung up to dry. Have the class note the difference in the two pieces of cloth.

Let the children try the same activity, but let them try putting different things on the cloth, such as jelly or chocolate. Which substance is easier to wash out of the cloth?

*Ask pupils what they see in the picture on these two pages. Ask if they have ever done or seen these things.*

# 3 PUSHES AND PULLS




## KEY CONCEPTS

**Key Concept 1.** Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

**Key Concept 4.** All objects in the universe and all particles of matter are constantly in motion; man has discovered and stated the laws governing their motion.

**Key Concept 5.** The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.

**CONCEPTS:**

1. It takes a force to move an object.
2. Work means the ability to push or pull something over a distance.
3. There are different kinds of forces (magnetic, human, gravity).
4. A machine is something people use to help push or pull an object.
5. We move something by pushing or pulling it.
6. Wheels help us move things.
7. The seesaw can do work. It can help you lift someone into the air.

## What makes things move?

*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



8. All seesaws rest on a support near the center (the fulcrum).
9. Two children, or objects, of equal weight will balance perfectly if the center of the board rests on the fulcrum.
10. Two things affect balance: weight and length of arm. A large weight at a small distance on one side balances a small weight at a large distance on the other side.
11. Machines can be used in applying force to move objects or to keep them from moving.
12. Magnets do not have to touch objects to exert force on them. (Magnetic forces act through certain substances).
13. Magnets pull things made of iron and steel.
14. The two ends of a magnet do not act in the same way.
15. Unlike ends of magnets are attracted to each other. (They pull toward each other.)
16. Like poles of magnets repel, and unlike poles attract.

**PROCESSES:**

- Observing—Pages 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60.
- Experimenting—44, 45, 49, 51, 52, 53, 55.
- Comparing—46, 47, 49, 54, 59.
- Inferring—48.
- Measuring—49, 56, 57.
- Classifying—50, 54.

TEACHING SUGGESTIONS

● **LESSON:** How can wheels help us move things?

**Background:** This lesson develops the two ideas of *work* and *machines*. The child thinks of work as labor or drudgery, although he may not use these words. But when anything is moved, work is done. To the scientist, a girl pushing a baby carriage and a boy pulling a wagon are both doing work. Carriages and wagons are used to carry things more easily. This is what a scientist means by a machine.

**Learnings to Be Developed:**

We move something by pushing or pulling it.

Wheels help us move things.

**Developing the Lesson:** Have children look at the picture on page 46 and discuss what is in Jim's wagon.

- *Why did Jim put the groceries in his wagon?*
- *What part of the wagon makes Jim's work easier?* (Wheels.)
- *What is in Alice's doll carriage?*
- *Do you think the doll is heavy?*
- *Why is Alice pushing the doll in a carriage?* (Easier than carrying the doll.)

Jim pulls.
What happens?

Alice pushes.
What happens?

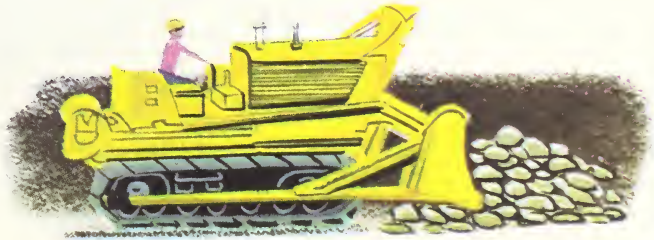
You must push or pull
a thing to start it moving.

# Machines Make Things Move

This is a machine.

Does it push?
Does it pull?
What does it move?

This is a big machine.



Does it push or pull?
What does it move?



**LESSON:** How can machines make things move?

**Learnings to Be Developed:** Machines make it easier for us to do work.

**Developing the Lesson:** Have children read the first two paragraphs on page 47 and answer the questions.

Have available the following simple machines: a nutcracker, ice tongs, scissors, and a can opener. Have the children operate the various machines, and then ask them if the machines help us do work. Ask them to tell what kinds of work the machines do.

- *What are some things that machines move? Describe some machines and tell how they move things.* (Carry, push, pull, slide, roll, turn, lift.)
- *What do you call a machine that you hold in your hand to do work?* (A tool.)
- *Describe some tools and tell how they move things.* (Screwdriver turns screw; hammer pushes nail into wood; saw cuts wood; pliers hold things.)
- Discuss safety with tools. (Scissors should be handed to someone else by the handle. When using a hammer, watch that no one is too near.)

TEACHING SUGGESTIONS

● **LESSON:** How does a seesaw move?

**Learnings to Be Developed:**

The seesaw can do work. It can help you lift someone into the air.

All seesaws rest on a support near the center (the fulcrum).

Two children, or objects, of equal weight will balance perfectly if the center of the board rests on the fulcrum.

Two things affect balance: weight and length of arm. A large weight at a small distance on one side balances a small weight at a large distance on the other side.

**Background:** The basic machine called the "first class lever" is made up of a bar, or rod, that is able to rotate on a point called a *fulcrum*. A good example of this is the seesaw.

Anne or Peter can be either the weight or the effort, depending upon the position of each one on the seesaw.

Two things affect the balance on a seesaw: weight and length of arm. A large weight at a small distance on one side balances a small weight at a large distance on the other side. If Anne and

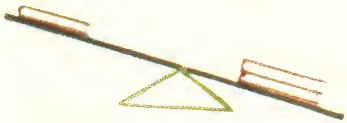
# The Seesaw Moves

A seesaw is a machine.
What does it move?

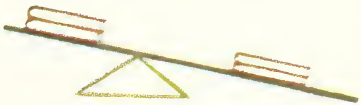
Anne and Peter want to seesaw.
Anne stays up in the air.
How can they make the seesaw go up and down?

What things are the same?
What happens when they are the same?

Look at this.
What is different?
What happened?



Look at this.
What is different?
What happened?



What can you do now?
Try this.

*The purpose of the diagrams and activities is to help pupils coordinate two variables: distance and weight. After pupils discover that both make a difference, ask, "If one weight is heavier, where shall we put it?" (Nearer the fulcrum.)*



Peter want to go up and down, Anne must move back or Peter must move toward the center.

**Developing the Lesson:** Read page 48 with the children. Have the children guess the answer to the questions. (Anne can try moving back to the end. If the board still doesn't go up and down, Peter can move toward the center.)

**Follow-Up:** Page 49 continues with the study of the seesaw, but with an important difference. The pupils are now presented for the first time with diagrams rather than realistic illustration. The diagrams present the principle of the seesaw in abstract form. They help the children form a mental image, or model, of the principle, and thus serve as an invaluable tool to help them think abstractly.

The basic concept involved in the seesaw balance is the concept of equilibrium—a state of rest is the result of forces counteracting each other. This concept is one that pupils will meet over and over again in the physical sciences as they learn to solve work problems. The concept is acquired gradually through a process of logical thinking. Readiness for the concept is developed here.

According to Jean Piaget, children go through clearly defined stages

in their growth toward logical thinking. At six years of age, the child is likely to have a vague feeling that the two things that influence the behavior of the seesaw are weight and length of arm (he may scoot up and down on the seesaw or ask a friend to sit with him to make it balance), but he has not identified the *relationship* between weight and length. Moreover, he is likely to manipulate variables on one arm of seesaw only, and not realize that variables on one side change with changes on the other side.

The last diagram is the child's first formal introduction to proportion, and it shows that as length is increased on one side, weight must be increased on the other. Help the children realize that they must increase the weight on the left side to make up for the increase in length on the right side. Conversely, when weight is increased on one side, they must increase length on the other.

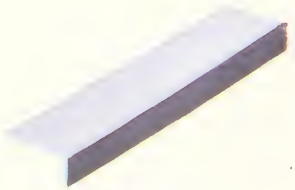
TEACHING SUGGESTIONS

**LESSON:** What do magnets do?

**Learnings to Be Developed:** Magnets pull things made of iron and steel.

*Permit pupils to work in groups with different kinds of magnets. Have each group report its findings to the class.*

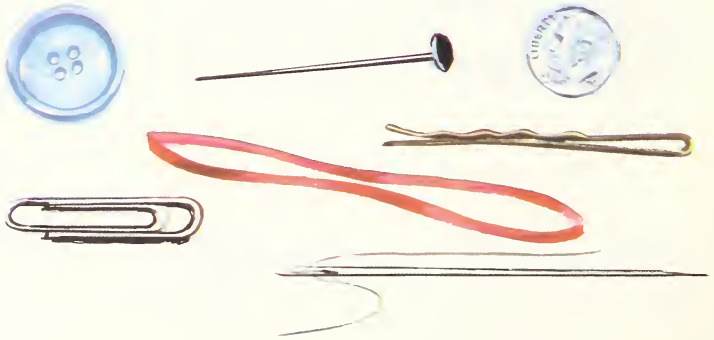
# Magnets Pull



This is a magnet.

This is a magnet.

Which things can a magnet pull?



Magnets pull through air.

Do this.

Why does the nail stay up?

Take the magnet away.
What happens?



**Developing the Lesson:** Have children look at the picture of the magnets.

- *Do all magnets look alike?*
- *Where else have you seen magnets?* (Magnetic toys and games, can openers, pot holders, magnetic mathematics boards, etc.)

Read the last sentence on page 50. Supply the children with magnets, and have them try to pick up various objects around the room. The children may divide these into two groups labeled "THINGS THAT MAGNETS PULL" and "THINGS THAT MAGNETS DO NOT PULL."

**Follow-Up:**

- *If a magnet picks up something, what must the thing have in it?* (Iron.)
- *What shapes are magnets?*
- *How does the picture on page 51 show that magnets pull through the air?*

**ADDITIONAL ACTIVITIES:**

Have the class make a list of ten small objects (penny, thimble, toothpick, match, etc.). After guessing which objects will be attracted by a magnet, have the class use a magnet on the objects to see which guesses were right.

## TEACHING SUGGESTIONS

● **LESSON:** Can magnets pull through glass?

**Learnings to Be Developed:** Magnets attract through glass.

**Developing the Lesson:** Bring some paper clips and a drinking glass to class. Read page 52 and have the children perform the simple operation shown on that page.

- *What will the magnet do?*

The children can make "Dancing Dolls." Put a pin into the cork of a bottle cap. Attach a paper doll to the pin. Put a flat piece of glass over two books and have the children use a magnet to move the dolls.

**Follow-Up:**

- *How does this activity show that magnets pull through glass?*

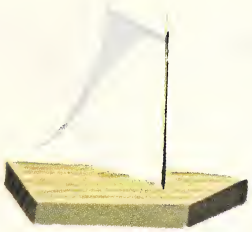
Magnets pull through glass.

Get this.

And this.

Try this.

# Magnets pull through water.

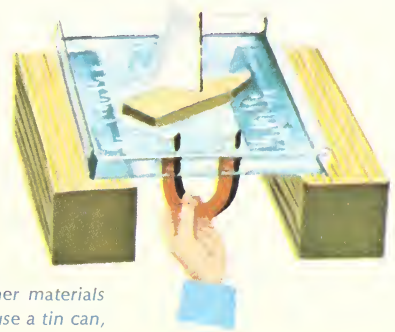


Make a boat.

Get these.

Do this.

Now do this.



What happens?

*Encourage pupils to find out what other materials magnetism travels through. Have them use a tin can, an aluminum pan, and a dinner plate.*

● **LESSON:** Can magnets pull through water?

**Learnings to Be Developed:** Magnets attract through water.

**Developing the Lesson:** Have each child make a boat. The boat should be not more than 1½" long. The children will need paper for a sail, two thumbtacks, and a paper clip. Have them construct the boat as illustrated. Have them try to move the boat after it is placed in water.

- *What is the magnet pulling through now?* (Glass and water.)

Encourage the children to find out what other materials magnetism can travel through.

**Follow-Up:**

- *What are some other things through which a magnet can pull?* (Paper, cloth.)

○ **ADDITIONAL ACTIVITIES:**

Have children tell about some of the ways they have used magnets. Many may have played games where magnets were used.

Make a paper fish. Put a paper clip on the head of the fish. Tie a magnet to the end of a string and let the children catch the fish.

TEACHING SUGGESTIONS

● **LESSON:** What happens when you bring together the ends of two magnets?

**Learnings to Be Developed:**

The two ends of a magnet do not act in the same way.

Unlike ends of magnets are attracted to each other. (They pull toward each other.)

Like ends of magnets repel each other. (They push away from each other.)

**Developing the Lesson:** You will need several magnets. It is necessary for first-graders to have the manipulative experiences to reinforce the abstract concepts learned.

Read the text with the children. Let them predict what will happen. Have as many children as possible try the magnets in the positions shown on page 54. Ask the children to tell the class what they have learned.

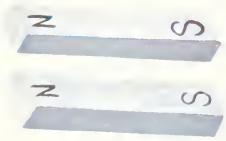
- *What ends are together if the magnets pull toward each other?* (Unlike ends are together.)

Direct the children's attention to page 55.

- *What ends are together now?*
- *What do you think will happen?*

# The Ends of a Magnet

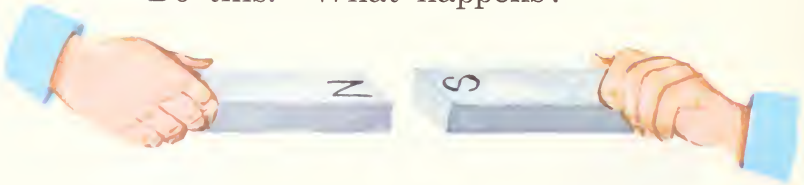
Look at the magnets.




N is for north.

S is for south.

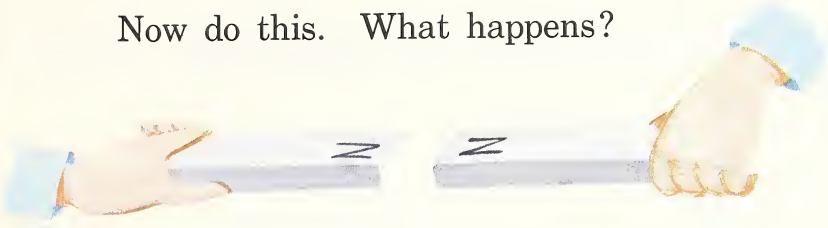
Do this. What happens?



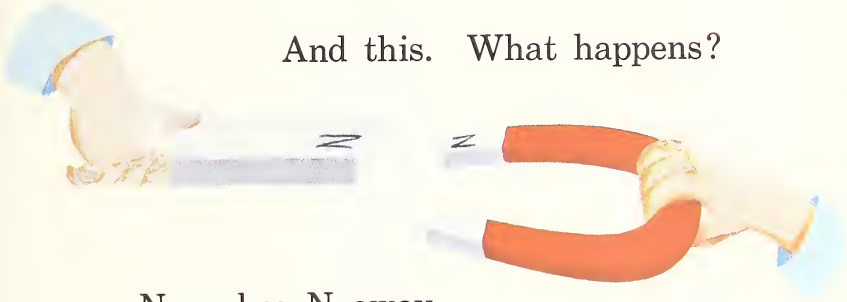

Do this. What happens?

N pulls on S. S pulls on N.
A magnet can pull on other magnets.

Now do this. What happens?




And this. What happens?




N pushes N away.

A magnet can push other magnets away.

Does S push S away? Find out.



Have several children try to put the like ends together. Have the children explain, in their own words, what happens.

- *When magnets push away from each other, what ends are nearest?* (Like ends.)
- *When magnets pull toward each other, what ends are nearest?* (Unlike ends.)

**ADDITIONAL ACTIVITIES:**

Before class time, test two magnets by holding them so they attract each other. Mark a dot on the left end of each of the magnets. Now try to match the magnets so that both dots come together. The magnets will repel each other. Children can demonstrate the principle that like ends repel and unlike ends attract.

Hold the magnets near each other. Let the children predict what will happen. Have several children try the magnets in the two positions (unlike ends together; like ends together.)

*What must you do if magnets are to pull each other?* (Unlike ends must be together.)

*What must you do if the magnets are to push each other away?* (Like ends must be together.)

TEACHING SUGGESTIONS

● **LESSON:** Are some magnets stronger than others?

**Learnings to Be Developed:** Some magnets are stronger than others.

**Developing the Lesson:** Page 56 will motivate the children to find out for themselves if some magnets are stronger than others.

Distribute magnets among the children. Let them hypothesize which magnets are strongest.

Have children put their magnets into a pile of paper clips or pins. Determine relative strength by the size of the cluster, the length of the chain, or the actual count.

- *Are some magnets stronger than others?*
- *How can you tell?*

**Follow-Up:**

- *Where is a magnet strongest?*

# How Strong Are Magnets?

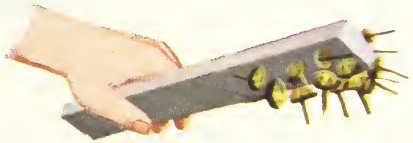
Get big magnets
and little magnets.

Are some magnets stronger
than other magnets?
How can you tell?

# Where Is a Magnet Strongest?

Do this.

A magnet is strongest at the ends.





**LESSON:** Where is a magnet strongest?

**Learnings to Be Developed:** A magnet is strongest at its ends.

**Developing the Lesson:** Have children read page 57. With their own magnets, have the children try to pick up paper clips, using various parts of the magnets.

Have the children make a "Fishing Game." (See page 53, Additional Activities.) Attach a paper clip to the mouth of each fish. Attach a small magnet to a string that is tied to a long stick. This is the fishing rod. Have the children experiment to find out which part of the magnet picks up the fish. (The end of the magnet.)

**Follow-Up:**

**Which parts of the magnet are strongest?*

**ADDITIONAL ACTIVITIES:**

Obtain a horseshoe-shaped magnet. Ask the children which part of the magnet is strongest. Use the magnet to repeat the demonstration on page 57.

TEACHING SUGGESTIONS

**LESSON:** How can you make a magnet?

**Learnings to Be Developed:** A magnet can be made by using another magnet.

**Developing the Lesson:** Tell the children the following problem:

- *There are eight children in a class, and they each want to play with a magnet. The teacher has only one magnet and some needles. What should she do?*

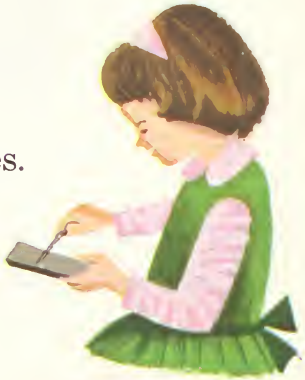
Let the children suggest various solutions. Give them a hint by asking them what the magnet and the needle are made of. When the children have exhausted all suggestions, have them open their books to page 58. Have a child read the page and tell what he thinks the girl in the picture is doing. Have several children try to make a needle into a magnet. (The children will discover that they must rub the needle in only one direction.) Have the children suggest things that the magnetized needle can pick up.

# Make a Magnet

Get this.

And this.

Do this many times.



Is the needle a magnet now?
How can you find out?

Your teacher will cut the needle.

*To insure safety for everyone, and make cutting easy, wrap a piece of cloth or paper around the needle you expect to cut.*

Is this a magnet?

Is this a magnet?

How can you find out?



After the children have used their needle-magnets to pick up things, cut a few of the needles in half. Ask the children if they think the small pieces still are magnets. Let the children try to pick up iron things with only half of the needle. Are both halves of the needle still magnets?

**Follow-Up:**

- *Can we make a magnet?*
- *Can we make a needle into a magnet?*
- *When you cut a needle-magnet in half, is the needle still a magnet?*

**ADDITIONAL ACTIVITIES:**

Have the children make a list of objects that they think can be made into magnets. Have the children bring these objects to class. Then, using the procedure shown on page 58, the children should try to make each object into a magnet.

TEACHING SUGGESTIONS

● **LESSON:** What is a compass?

**Learnings to Be Developed:**

The needle in a compass is a magnet.

The needle points to North.

**Developing the Lesson:** Have the children look at the compass on page 60. Most children are familiar with compasses. Before reading the text, try to draw from the children the fact that the needle in the compass is a magnet.

• *How can we tell if something is a magnet?* (Bring a bar magnet near the compass, but do not touch the compass case with the magnet. The north pole of the magnet will repel the north pole of the compass needle and attract the south pole of the compass needle.)

Have the children discover the direction in which the needle is pointing. Have them locate South on the compass. (It is not necessary to introduce East and West.)

Have a child walk to various parts of the room with a magnet. Where does N point? Have another child swing the magnet on a string. Let it stop swinging. Where does N point now?

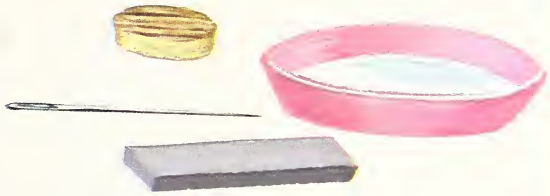
# A Compass

The needle in a compass is a magnet.

The needle points north.
Can you find south?

Hang up a magnet this way.
N will point north.
Push the magnet.
Let it stop.
Where does N point now?

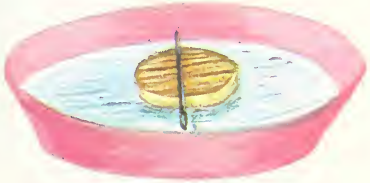
# Make a Compass



Get these.

Make the needle
into a magnet.

Do this.



Does the needle point north?
Find out with your compass.



Make a compass with the children. You will need the materials shown on page 61. Ask the children what they must do to the needle first. Then place the needle on a cork that has a groove in it. Float the cork in a basin of water. Compare the direction in which the needle is floating with the direction of a commercial compass.

**Follow-Up:**

- *What is the needle in the compass?* (A magnet.)
- *In what direction does the needle point?* (North.)

**ADDITIONAL ACTIVITIES:**

A compass needle enables you to find out what the unmarked poles of a magnet are. Magnetize a steel knitting needle. Have the children bring the knitting needle near the compass. Ask them to find out what the poles are.

## KEY CONCEPTS

**Key Concept 1.** Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

**Key Concept 8.** There is a relationship between structure and function; the structure of parts of living organisms determines the function of those parts.

**CONCEPTS:**

1. Only living things can grow.
2. Some things grow faster than other things.
3. Different parts of the body grow at different rates.
4. Different children grow at different rates.
5. Animals and plants grow.
6. Bones grow; teeth grow.
7. There are many different sizes and shapes of bones in the body. Each bone has a certain job to do.
8. Strong bones are needed for work and play.
9. X rays can be used to tell if bones are broken.
10. Broken bones must be set.
11. Different kinds of bones look different.
12. Bones have marrow inside them.

Comparing and measuring are two important skills in science to be learned through this unit

# 4 GROWING UP

Don and Mary grew.
Which parts grew most?

*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



13. Children have two sets of teeth.
14. Baby teeth are replaced by permanent teeth.
15. You must take good care of baby teeth by brushing them and by eating proper foods so that the permanent teeth will grow the way they should. Four permanent teeth (the six-year molars) appear during the sixth or seventh year.
16. Different teeth have different functions.
17. Brushing the teeth after eating is effective in preventing cavities.
18. Proper food and brushing help teeth to grow strong.
19. As we grow, our behavior changes (feelings).
20. There are appropriate ways to behave while playing with others.
21. We can learn how to play with others.
22. We should be considerate if we want to play with others.
23. Proper exercise and rest help us to grow strong.

**PROCESSES:**

- Observing—Pages 63, 64, 65, 66, 68, 70.
- Comparing—63, 64, 65, 66, 77.
- Inferring—63, 64, 65, 70, 77.
- Classifying—66.
- Explaining—70.

TEACHING SUGGESTIONS

● **LESSON:** How do children differ in how fast they grow?

**Learnings to Be Developed:** Children grow at different rates.

**Developing the Lesson:** Read page 64 and have the children discuss the ways in which the children shown on the page look different.

- *Which is the best way to look?* (There is no one best way to look. Looking neat and clean is what is important.)
- *Do some boys and girls have longer arms and legs than others?*
- *What do you notice about children in later grades? Are there also differences in how tall or short they are?*
- *Are your parents tall or short?*
- *Do some children grow faster than others?*

**Follow-Up:**

- *Do all children grow at the same rate?*

○ **ADDITIONAL ACTIVITIES:**

The class can start a chart called "Growing Taller." Measure each child's height, and write the measurement on the chart. Every week, enter the child's height measurement. Note any growth changes that occur.

Some children grow faster than other children. These children are all six years old.

How are the children different?

# What Things Grow?

Does a rock grow?

Does a plant grow?

Does a kitten grow?

Plants and animals grow.



● **LESSON:** What things can grow?

**Learnings to Be Developed:**

Only living things can grow.

Some things grow faster than other things.

**Developing the Lesson:** Have children read page 65 and discuss which things on the page can grow. Have the children list other things that can grow, as well as some things that cannot grow.

- *What does something have to be if it grows?* (Alive—plant or animal.)

This is a good time to measure the children's height and weight. Have them compare their measurements of this year with their measurements of last year. Did some of the children grow more than the rest of the children?

○ **ADDITIONAL ACTIVITIES:**

Have the children plant some bean seeds in water. Have the children note any ways in which the new plants change as they grow.

# Bones

TEACHING SUGGESTIONS

**LESSON:** What do bones do in our bodies?

**Learnings to Be Developed:**

There are many different sizes and shapes of bones in the body. Each bone has a certain job to do.

Strong bones are needed for work and play.

X rays can be used to tell if bones are broken.

Broken bones must be set.

**Developing the Lesson:** Look at the pictures on pages 66 and 67 and discuss them with the class.

- *What does the picture on page 66 show?*
- *Where is your skeleton found?*
- *What is your skeleton made of?*

If possible, obtain actual X-ray pictures from a doctor or a hospital. Let each child in the class examine the X rays and try to feel his own body to locate some of his own bones.

- *How do bones help us?* (They protect internal organs, provide flexibility, and shape for the body. Demonstrate by twisting a rag doll into a number of improbable positions.)

Bones grow.
Find some long bones.
Find some little bones.

Sometimes a bone breaks.
A doctor can see the bone
on an X-ray picture.

The doctor must set the bone.
The bone will grow together.



**Follow-Up:**

- *What do bones do in our bodies?*

Discuss the kinds of things that children do that might endanger them, such as climbing where it is not safe or hanging on to moving objects. Ask if any of the children have ever had a broken bone.

- *What happens if a bone breaks?*

Let the children discuss their own experiences of having broken bones.

- *What did the doctor do?*
- *How does the doctor know what part of the bone is broken?* (He takes an X ray.)
- *Why did the doctor shown on page 67 put a cast on the boy's arm?* (To protect the bone and help keep it in place while it mends.)

**ADDITIONAL ACTIVITIES:**

Have some branches on hand and let pupils break them. It would be interesting to compare the way a green stick (branch) breaks with the way a dried stick breaks. Children's bones are softer than adults' bones, and they break somewhat the way the green stick breaks.

## TEACHING SUGGESTIONS

● **LESSON:** What are the bones of a chicken like?

**Learnings to Be Developed:**

Different kinds of bones look different.

Bones have marrow inside them.

**Developing the Lesson:** Let the children examine the breastbone, the wing bone, and the leg bone of a chicken.

- *How do the bones look different from one another?* (Leg bone is *long;* wing bone is *shorter;* breastbone is *flat.*)

Have the children compare the different bones, and ask them to try to explain why they think each bone is different.

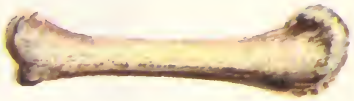
Break a leg bone and have the children identify the marrow.

**Follow-Up:**

- *How are bones different?*
- *What is inside bones?*

○ **ADDITIONAL ACTIVITIES:** Break a leg bone of a chicken and examine the fracture with the class. Look at the fracture with a hand lens and examine the structure of the bone. Call attention to the marrow in the center of the bone.

These are chicken bones.
Get some chicken bones.

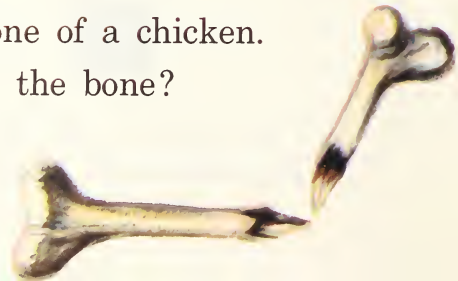


Wing bone

Breastbone

Leg bone

Break a leg bone of a chicken.
What is inside the bone?



# How Do Teeth Grow?

Sally's baby teeth are coming out.
New teeth are growing under them.
She cannot see them yet.
The dentist can see them
on an X-ray picture.

*If possible bring in an X-ray picture and an ordinary film negative for comparison.*

**LESSON:** How do your teeth grow?

**Learnings to Be Developed:** Children have two sets of teeth.

**Developing the Lesson:** Start the lesson by asking a question about page 69.

- *Who do you think has taken the X-ray picture shown on page 69?*

Have the children describe their own experiences at the dentist's office.

- *How often should you go to the dentist?*
- *What happens at the dentist's office?* (He fills cavities, cleans teeth, and takes X-ray pictures.)

Have the children use a mirror to look into their mouths. (Many children will see spaces where their baby teeth have fallen out.)

- *What will come up in the empty spaces?*

**Follow-Up:**

- *What takes the place of our baby teeth?*

**ADDITIONAL ACTIVITIES:**

Some of the children might try to obtain X-ray pictures taken by a dentist. Have the children bring the X-ray pictures to class for discussion.

TEACHING SUGGESTIONS

● **LESSON:** Why must you take care of your teeth?

**Learnings to Be Developed:**

Baby teeth are replaced by permanent teeth.

You must take good care of baby teeth by brushing them and by eating proper foods so that the permanent teeth will grow the way they should. Four permanent teeth (the six-year molars) appear during the sixth or seventh year.

Different teeth have different functions.

**Developing the Lesson:** This lesson is designed to help children understand why it is so important to take good care of baby teeth.

Let children explore with their tongues to find out if they are getting, or already have, a six-year molar. It is the first of their permanent teeth.

Give each child a small piece of apple to eat. Have each child try to break the piece of apple without using his teeth. Then, give another piece of apple to each child, and have each child chew with his teeth.

• *Which teeth did you use to bite the apple?*

Sally will get new teeth in back too.
There are no baby teeth there.

Sally's new teeth will look like this.

How many teeth will Sally have?

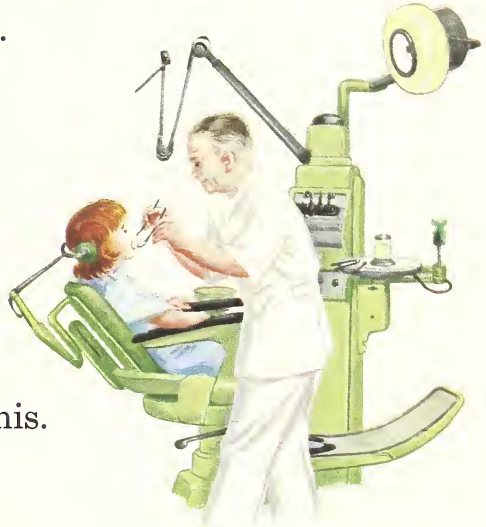
Sally must take care of her teeth.

Can you tell why?

*the dentist can tell the children what he finds out from studying X-ray pictures. (He sees new teeth and can tell whether they will grow straight.)*

# Taking Care of Your Teeth

You can do this.



And this.

You can eat these foods.
They make teeth strong.

- *Which teeth did you use to chew the apple?*

○ **ADDITIONAL ACTIVITIES:**

Write to a large pharmaceutical company or to a large manufacturer of toothpaste products, and ask for dental health charts or brochures for classroom use.

● **LESSON:** How can you take care of your teeth?

**Learnings to Be Developed:** Brushing the teeth after eating is effective in preventing cavities.

**Developing the Lesson:** Have children read page 71 and discuss various ways they take care of their teeth (brushing, going to dentist, eating proper foods).

The correct way to brush teeth can be demonstrated by smearing peanut butter over a clean comb. Use a toothbrush to remove the peanut butter caught between the teeth of the comb.

- *What is the best way to move the toothbrush when you clean the comb?* (Up and down.)
- *What do you think is the best way to move the toothbrush when you clean the sides of your teeth?* (Up and down.)

TEACHING SUGGESTIONS

- **LESSON:** How should you play with others?

**Learnings to Be Developed:**

There are appropriate ways to behave while playing with others.

We can learn how to play with others.

We should be considerate if we want to play with others.

**Developing the Lesson:** Role-playing is a good way to help children face personal problems. To help children see another point of view, reverse the roles so that the children play both child and parent, insider and outsider.

- *What is happening in the pictures on page 72?* (Two children are *not* playing.)
- *Have you ever had this happen to you? What did you do?* (Point out that we can usually choose the way we behave. There are many ways a child can act in each situation—constructively or destructively.)

# Playing with Others

Ted wants a turn.
What can he do?

Judy is a new girl.
She wants to play.
How can the children help Judy?

*going on in each picture. Point out that we can usually choose our behavior.*

David wants to play.

Fred can say, "Go away, David. We don't want you."

Or he can say, "You can play after this time."

What should Fred say?



Have children dramatize the situations on page 72. Then reverse the roles.

- *How did it feel when you were playing but the other children were not?*
- *How did it feel when the other children were playing but you were not?*

Read and dramatize the activity on page 73. Have one child play Fred and then David. He will see how it feels to act destructively and constructively.

**Follow-Up:**

- *How can we change the ways that we behave toward others?*
- *How can we be more thoughtful of others' feelings?*
- *How can we make children who are new in our school or neighborhood feel welcome?*

TEACHING SUGGESTIONS

● **LESSON:** What can you do if you feel angry?

**Learnings to Be Developed:** Children can develop constructive ways to handle their feelings of rejection and anger in relation to others.

**Developing the Lesson:** Have the children read and offer ideas about how Larry may feel.

- *How could you get rid of angry feelings such as Larry's?* (Help the children to conclude that talking to someone else about their feelings, or finding something else to do, is often better than directly expressing their angry feelings. Another way is to dramatize. Have the children act out the situations on page 74.)

**Follow-Up:**

- *What can you do if you feel angry at your parents?*

Bob is Larry's brother.
Father is playing with Bob.
Father is not playing with Larry.

How does Larry feel?
What can Larry do?

Mother does not have time to play with Peggy.
How does Peggy feel?
What can Peggy do?

*Ask how Peggy could help her mother. How do pupils help at home?*

# Exercise

Your heart beats.
Your heart sends blood to every part of your body.

Jump up and down many times.

Your heart will beat faster.
It will send blood faster.

Exercise helps to keep you well.

Here are some ways to exercise.
Do you exercise every day?

● **LESSON:** Why is exercise important?

**Learnings to Be Developed:** The heart beats faster when you exercise.

**Developing the Lesson:** Start a discussion based on page 75.

- *Where is your heart?*
- *How do you know it is there?* (You can feel heartbeat.)
- *What does your heart do?* (It pumps blood throughout your body.)
- *In how many places can you feel your "pulse"?* (Explain that the "pulse" is any part of the body where the blood pressure can be felt near the skin, such as in the wrist.)

Have the children read page 75. Have them jump up and down a few times. Then have them verify their guesses about the locations of pulse beats. Have them feel the pulse in their necks, wrists, and temples.

**Follow-Up:**

- *What does the heart do?*
- *What must we do every day in order to help ourselves stay well?*
- *What are some of the exercises you do?*

TEACHING SUGGESTIONS

● **LESSON:** Do animals need rest?

**Learnings to Be Developed:** Animals need rest.

**Developing the Lesson:** Have the children read page 76.

- *In what positions are the animals resting?* (Curled up, stretched out, etc.)

Have the children compare the animals' positions to that of a sleeping human baby.

- *Where do animals rest?* (Some animals rest on the ground, some crawl into the ground, some rest on the limb of a tree.)

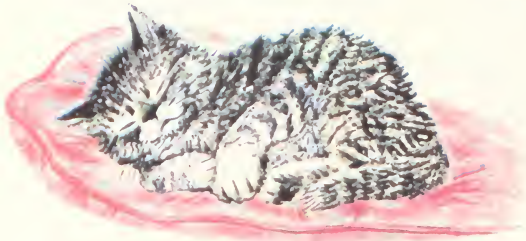
**Follow-Up:**

- *Do animals rest?*
- *Where do animals rest?*

**ADDITIONAL ACTIVITIES:**

Make a bulletin board display of pictures of animals resting. Some of the brighter pupils in the class might try to find out if insects and fish need rest, and how they get their rest.

# Rest



Animals need rest.
Some animals rest by sleeping.
How do you rest?

# Bedtime

It is 7 o'clock.
It is bedtime.
It is winter.

It is 7 o'clock.
It is bedtime.
It is summer.

What is different?
Does this happen where you live?



● **LESSON:** When do you need rest?

**Learnings to Be Developed:**

Bedtime is one of the times you rest.

Days are longer in the summer than in the winter.

**Developing the Lesson:** Have the class look at the pictures on page 77 and then discuss them.

- *Why do you think the girl in the bottom picture finds it hard to go to sleep?* (Sometimes it is dark at bedtime and other times it is light. Try to have the children explain why.)
- *When you stay up late at night, how do you feel the next day?*

Explain that muscles and bones grow and repair themselves while you are asleep.

**Follow-Up:**

- *Why is rest so important?*
- *At what time of year is it daylight when you go to bed?*

TEACHING SUGGESTIONS

● **LESSON:** Why is it sometimes hard to fall asleep?

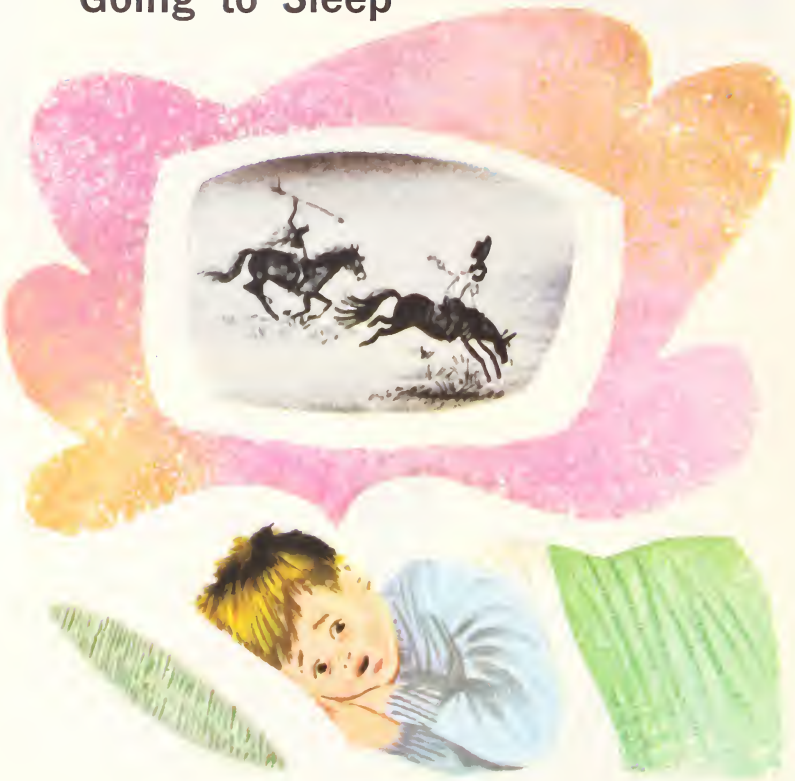
**Learnings to Be Developed:** It may be hard to fall asleep after watching a frightening program on television before bedtime.

**Developing the Lesson:** The story in this lesson suggests a source of some fears that children may have when they go to bed. Watching television programs that show violence or threatening situations sometimes creates anxiety and fear that may be carried over to bedtime or to other situations.

Introduce the story on pages 78 and 79 by asking the children how many of them ever had bad dreams after watching television.

Say, "The story I am going to read to you is about a boy who watched a scary television program before he went to bed. Let's see what happened."

# Going to Sleep



Ben cannot go to sleep.
He is thinking of what he saw on television.



*Talk with children about the TV programs they watch. Perhaps you can suggest alternates for ones you feel are not appropriate. Perhaps you can make a list of suitable programs and distribute it to the youngsters. Many*

Ben is afraid.

He is afraid of what he thinks he hears.

He does not know what he hears.

What does Ben really hear?



Read the story to the children or ask an advanced reader to read it.

- *How do you think Ben felt as he watched the program?* (He probably was scared.)
- *Why couldn't Ben sleep that night?*
- *Why do you think Ben was afraid?*
- *Was there really someone or something for Ben to be afraid of?*
- *How do you think Ben can get rid of his feeling of being afraid?*
- *Were you ever afraid after watching such a television program?*
- *What did you do?*
- *Do you still get such feelings?*
- *What do you do now?*

**Follow-Up:**

- *To make certain you do not feel afraid when you go to sleep, what might you do?*

## TEACHING SUGGESTIONS

● **LESSON:** What things may make you afraid at bedtime?

**Learnings to Be Developed:** Many children have the same nighttime fears.

**Developing the Lesson:** Let the children relate dreams that have awakened them at night. Try to find out what such dreams were about. (Airing their fears and finding out that others have the same fears can often help children to overcome such fears.)

- *What is Mary afraid of?* (She sees the shadows of branches on her wall.)
- *What can Mary do?*
- *What can you do if you are afraid at bedtime?* (Try to think of pleasant things, try to figure out the cause of the "thing," turn on the light to see what it is.)

**Follow-Up:**

- *What can you do when you are afraid at bedtime?*

Nancy is afraid.

She is afraid of what she thinks she sees.

She does not know what she sees.

What does Nancy really see?



*Note the shadows of the branches on the wall.*

# Telling Someone

It helps to tell someone when you are afraid.

Nancy is telling her mother.

Nancy feels better now.

**LESSON:** How does telling your feelings to someone help you feel better?

**Learnings to Be Developed:** It helps to talk over your fears with someone.

**Developing the Lesson:** Read the text on page 81 and discuss the picture.

- *Do you think Nancy feels better after talking about her feelings with her mother?*
- *How can you tell?* (Nancy looks less afraid.)
- *Why is it that sometimes you do not want to talk about your feelings with others?* (Perhaps the children will express some of their own feelings, such as fear of being laughed at, being ashamed to tell, or not being sure what the other person might think.)

**Follow-Up:**

- *What would have happened if Nancy had not told her mother about her feelings?* (Nancy probably would have believed something was there when it really wasn't.)

## KEY CONCEPTS

**Key Concept 1.** Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

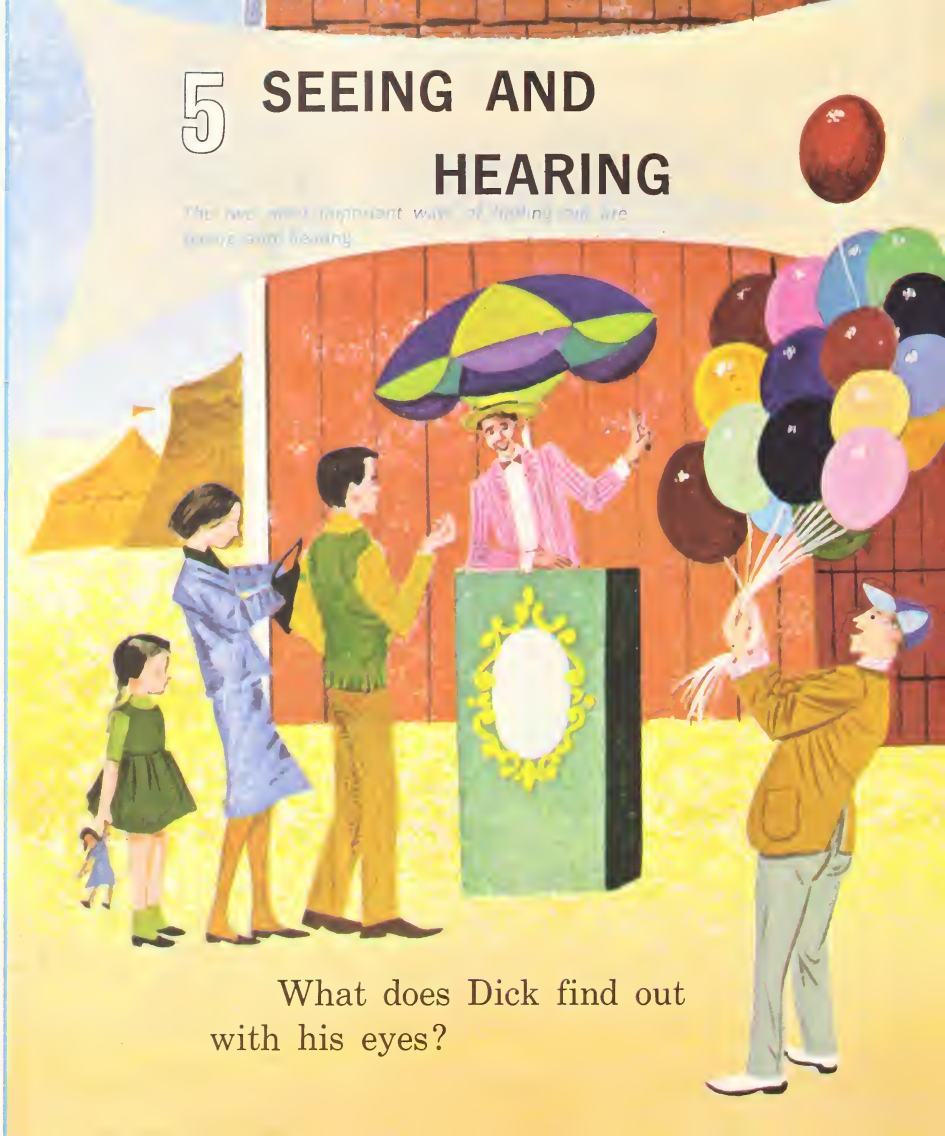
**Key Concept 5.** The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.

**Key Concept 8.** There is a relationship between structure and function; the structure of parts of living organisms determines the function of those parts.

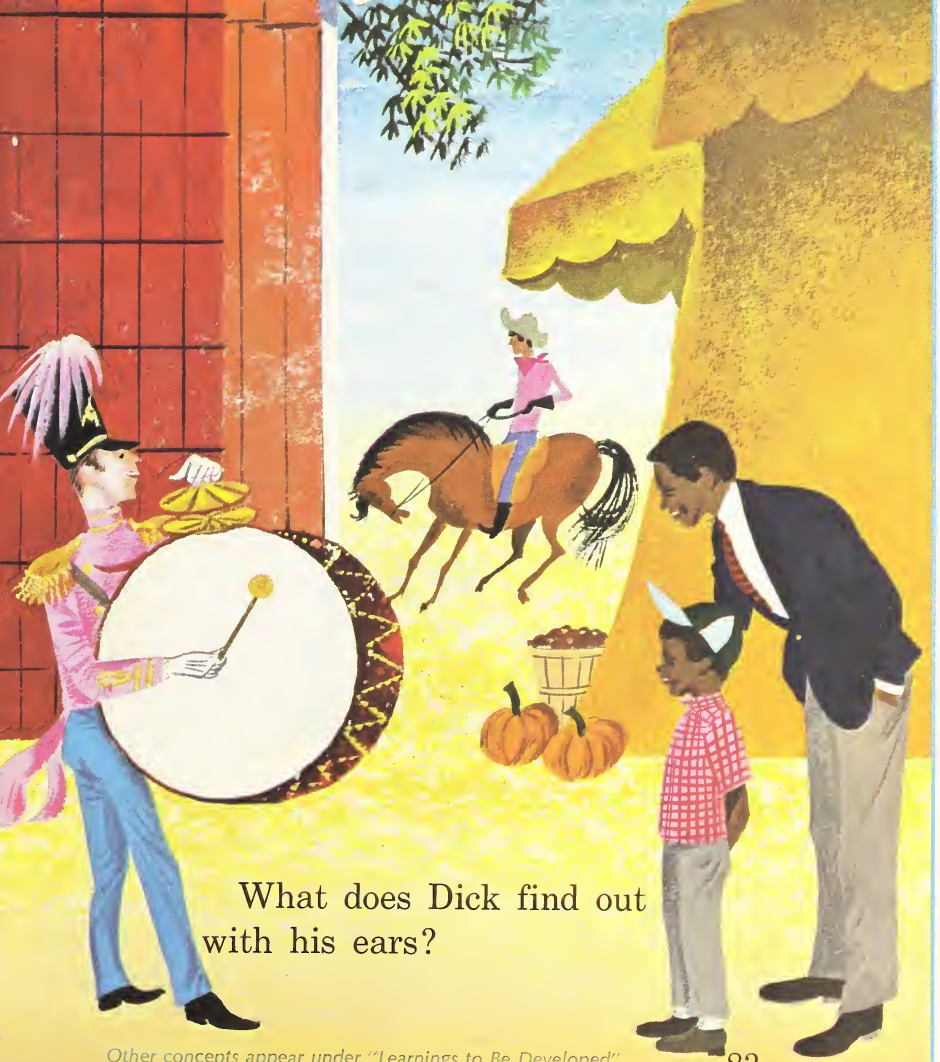
**CONCEPTS:**

1. We find out many things by using our eyes and ears.
2. Our senses of sight and hearing help us to learn about our environment.
3. We need light to see.
4. There are ways to shine light on things so that you can see them better.
5. White light is made up of different colors.
6. A rainbow is caused by light reflected from drops of rain.
7. A prism helps you to see the colors that are in white light.

# 5 SEEING AND HEARING



What does Dick find out with his eyes?



What does Dick find out with his ears?

*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



8. Different colors can be screened out by using different colors of cellophane.
9. Colored glass or cellophane does not add a color to white light. Rather, it takes away all colors except its own. Only the color of the glass or cellophane can go through.
10. Lights are used as signals.
11. Traffic lights are actually white lights behind colored glass.
12. Traffic lights are used as signals.
13. It is important to obey the traffic lights.
14. Traffic lights are placed at intersections to protect you.
15. It is important to be careful even when the light is green.
16. Our vision and hearing can be tested.
17. Vibrating objects produce sound.
18. You can hear the heart as it pumps blood.
19. The heartbeat can be heard more plainly through a stethoscope.

**PROCESSES:**

- Observing—Pages 82, 83, 84, 85, 86, 90, 91, 92, 93, 94, 95, 96, 97.
- Experimenting—87, 88, 89, 92, 93, 95, 96.
- Comparing—84, 85, 86, 92, 93, 96.
- Inferring—92, 93.

TEACHING SUGGESTIONS

● **LESSON:** What do you need to help you see?

**Learnings to Be Developed:** You need light to help you see.

**Developing the Lesson:** Cut off the sources of light in the room by drawing the shades and turning off the overhead lights. Hold an object in front of you and ask the children to identify it.

- *What will make it easier for you to see the object?* (Allowing more light to shine on the object.)

Pull up the shades and turn on the lights.

- *How did pulling up the shades and turning on the lights help you to see the objects better?* (More light fell on the object.)
- *Where does light come from?* (The sun, electric bulbs.)
- *What else gives light?* (Flame—see page 84.)

**Follow-Up:**

- *What must we have in order to see?*

We need light to see.
These things give light.

We can shine light on things.
Then we can see them.

**LESSON:** What can you do to see things better?

**Learnings to Be Developed:** There are ways to shine light on things so that you can see them better.

**Developing the Lesson:**

- *What is the boy in the picture on page 85 doing?* (Using a flashlight.)
- *Why is he using a flashlight?* (So he can see things better.)
- *Is there any other source of light shown in the picture?* (The moon.)
- *How do you know?* (You can see the outlines of light on the boy and his father; also on the leaves of the tree. Without light, the outlines could not be seen.)

**ADDITIONAL ACTIVITIES:**

Darken a room so there is no light entering it. Holding up a piece of chalk in front of the class, ask if anyone can see the chalk. Then shine a flashlight on the chalk. Ask the children what happens when the light is turned on. Introduce the idea that when light from the flashlight hits the object and is bounced back to their eyes, the children can then see the object.

TEACHING SUGGESTIONS

● **LESSON:** What are the colors in light from the sun?

**Background:** Sunlight is made up of seven colors: red, orange, yellow, green, blue, indigo, and violet. When sunlight enters raindrops at certain angles, the light is broken into rays of the separate colors. The inner surface of the raindrop acts like a mirror and reflects the different colored rays of light down into the eyes of anyone looking up from the proper place on the ground.

When the sunlight is broken up, the colors always arrange themselves in the order listed above. This is called the *spectrum*. In the rainbow, the red will be at the top. But if there are two rainbows, violet will be at the top of the larger, secondary rainbow.

When sunlight, or any white light, passes through a prism, the same thing happens that happened in the raindrops. But the rays of color pass straight through the prism instead of being reflected. The shape of the prism allows the rays to pass through.

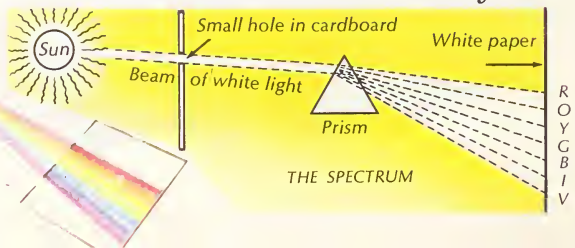
**Learnings to Be Developed:**

A rainbow is caused by light reflected from drops of rain.

# Colors in White Light

The sun gives white light.
There are colors in white light.
A rainbow is made of white light.
You can see the colors in a rainbow.

You can see the colors this way.



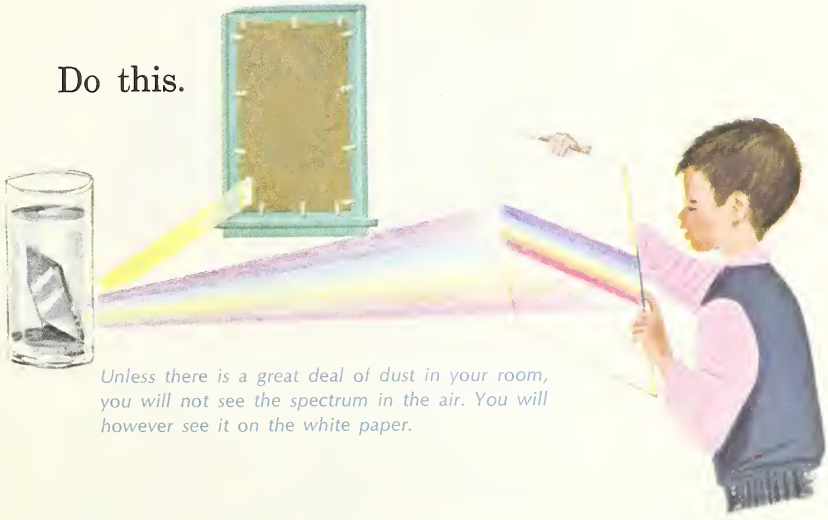
## Get these.

Mirror

White paper

*Do this demonstration step by step for a vivid illustration of how colors are obtained. First put the mirror in water. Then mount the cardboard sheet with a thin slit in it on the window.*

## Do this.



*Unless there is a great deal of dust in your room, you will not see the spectrum in the air. You will however see it on the white paper.*

## Do you see the colors on the paper?



A prism helps you to see the colors that are in white light.

**Developing the Lesson:** Since rainbows show the various colors in light, start with a discussion of this familiar phenomenon.

- *When do you see a rainbow?*
- *What colors are in a rainbow?*
- *Where can you see rainbows?*

Another way to demonstrate the colors in white light is by using the items on page 87. In order to have a clear spectrum (band of colors), place the mirror in the glass of water so that it faces strong sunlight. In both experiments, light is bent as it enters and leaves the transparent glass, with each color in the spectrum bent at a different angle. The colors are not visible as they pass through air. (Note: In the illustrations on pages 86-89, the spectrum of light *is* visible between the prism or mirror and the piece of paper. This has been done for illustrative purposes only.)

**ADDITIONAL ACTIVITIES:**

- Use a hand sprayer filled with water. Stand with your back to the sun and operate the sprayer. Look for the rainbow. This is similar to the rainbow seen in the sky. A fine spray from a hose will also produce a rainbow.

## TEACHING SUGGESTIONS

●**LESSON:** How can you get one color from white light?

**Learnings to Be Developed:** Colored glass or cellophane does not add a color to white light. Rather, it takes away all colors except its own. Only the color of the glass or cellophane can go through.

**Developing the Lesson:** Using a mirror in a glass of water (see page 87), reflect a spectrum onto a piece of white paper. Have the children name the various colors they see.

Place a transparent sheet in front of the paper.

- *Have the colors changed?*
- *What do you think would happen if a piece of blue cellophane were placed in front of the white paper?*

White light has many colors.
How can you get one color?

*Insert a blue sheet of cellophane between the mirror and the image of the spectrum. Children can see that although the same colors are being reflected from the mirror, something happens to them as they pass through the blue.*

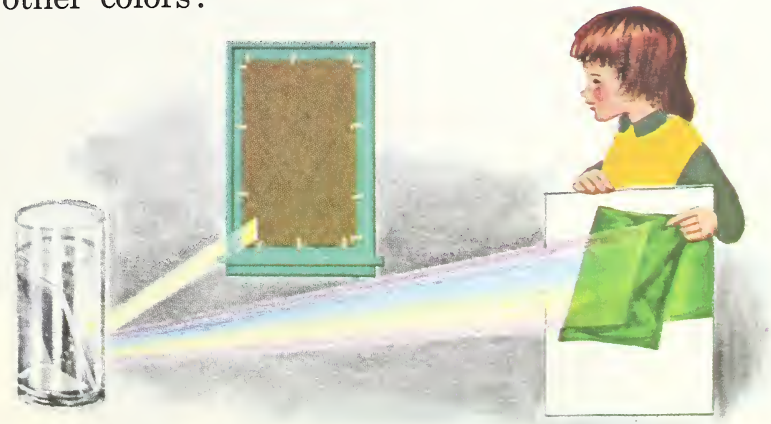
Do this.

*Do the same demonstration with red and green cellophane sheets.*

What color do you see on the paper?
Blue takes away the other colors.

Tim wants red light.
He takes away the other colors.

Jane wants green light.
How does she take away the other colors?



Have one child, or perhaps the entire class, place a piece of blue cellophane in front of the white paper.

- *What does the blue cellophane do to the white light?*

Most first graders think that a piece of colored cellophane adds a color to the white light. However, what actually happens is that the other colors are absorbed, or "soaked up," by the blue cellophane. Only the blue color passes through.

Repeat the activity, using red and then green cellophane. Let the children experiment with many different colors.

**Follow-Up:**

- *What colors are in white light?*
- *What does a clear, flat piece of glass let white light do?*
- *What happens to the colors in white light when they pass through differently colored pieces of cellophane or glass?*

*of safety?*

# Traffic Lights

The lights tell when to go.

The lights tell when to stop.

TEACHING SUGGESTIONS

● **LESSON:** Why are traffic lights important?

**Learnings to Be Developed:**

Traffic lights are actually white lights behind colored glass.

Traffic lights are used as signals.

It is important to obey the traffic lights.

Traffic lights are placed at intersections to protect you.

It is important to be careful even when the light is green.

**Developing the Lesson:** Review traffic safety rules with the children.

- *Why is a red traffic light red?* (Some children may think there is a colored bulb behind the glass. Actually, there is a piece of colored glass in front of a white light bulb.)

Try to help the children to understand that even in a colored bulb, the glowing filament inside gives off a white light, not red or green. Let the children watch an unfrosted bulb (15 watt) to see that the light it gives off has virtually no color.

Have pupils shine a flashlight through a piece of thin, flat, clear glass to see that light passes through with no discernible

# Testing Your Eyes

What is this girl doing?

*To understand the world around you, you must be able to see well. Scientific instruments are used to check eyesight. Scientists have found out how to correct many eye defects. Point out that if you find out early enough what is wrong with your eyes they sometimes can be corrected. This is one important reason for having a medical checkup.*

Some children do not see well.
What can help them see better?



changes. Then, have pupils shine the flashlight through a variety of colored transparent materials.

- *What color comes out each time?* (Try to establish the fact that something happens to white light as it passes through a colored material.)
- *What is the green (or red) cellophane doing to the white light?* (If the children answer, "It changes the color" or "It makes the white light green," ask, "How does it do this? Does the green cellophane add something or take away something from the white light?")

● **LESSON:** How can you care for your eyes?

**Learnings to Be Developed:**

Light enables you to see.

Instruments can help check how well you see.

There are ways to help you if you do not see well.

**Developing the Lesson:** Relate the learnings on pages 84 and 85 to this lesson.

Have someone who wears glasses explain how his eyes were tested by the doctor. Have the child also explain how he takes care of his glasses.

TEACHING SUGGESTIONS

● **LESSON:** What makes a sound?

**Learnings to Be Developed:** To have sound, an object must move back and forth (vibrate).

**Developing the Lesson:** Have the children read and perform the activity on page 92. It is very important that each child perform the simple operations shown. Tactile experience greatly aids the first grader in learning.

Have the children report to the class what they have seen and heard (the objects moved; the children heard a sound).

At this point, introduce the word *vibration*, referring to the quick back-and-forth movements of the stick and the triangle shown on page 93.

What will happen if you stop the ruler from moving? (The sound will stop. Tell the children, "When we hear a sound, something is vibrating. Sometimes we can feel the vibration even though we cannot see it." Ask the pupils to give examples.)

Read page 93 and demonstrate the activity for the class. You can give an exciting demonstration of how an object making a sound is moving rapidly (vibrating). Put a

# What Makes a Sound?

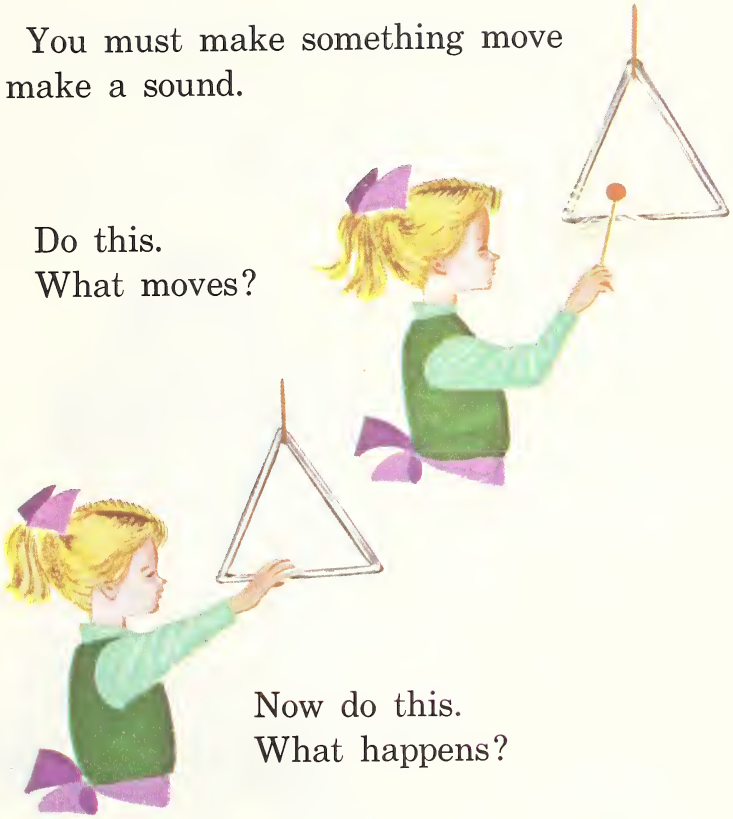
Hit the stick.

What do you see?
What do you hear?

Do this.

What do you see?
What do you hear?

You must make something move to make a sound.



Do this.
What moves?

Now do this.
What happens?

You can stop something that moves.
Then the sound stops.



vibrating tuning fork into a basin of water. The children will see a splash.

**ADDITIONAL ACTIVITIES:**

Help the children to become more aware of sounds and the role that sound plays in their environment. You learn to identify things by the sounds you associate with them.

Try the following activities. Have the children close their eyes and guess what each sound is:

- Someone walking
- Someone running
- Bell ringing
- Drum beating
- Ball bouncing
- A whistle
- Clock ticking
- Someone writing on board
- Different animal sounds

Drop a button, or drops of water, from your hand into a pan of water. Watch the waves moving out in all directions. Sound waves go out in the same way. A pebble thrown into a pond or lake will create a more distinct wave pattern.

Try striking various objects for sound and pitch. Use paper, wood, glass, cloth, or metal. Do they sound alike or different? Have the children try to describe the differences.

TEACHING SUGGESTIONS

**LESSON:** What helps the doctor to hear sounds in your body?

**Learnings to Be Developed:**

You can hear the heart as it pumps blood.

The heartbeat can be heard more plainly through a stethoscope.

The stethoscope has three parts: ear pieces, a contact piece, and a hollow tube connecting the ear pieces and the contact piece.

The stethoscope enables the doctor to hear the heart more plainly because it helps to shut out interfering sounds and carries the sound of the heartbeat directly to his ears.

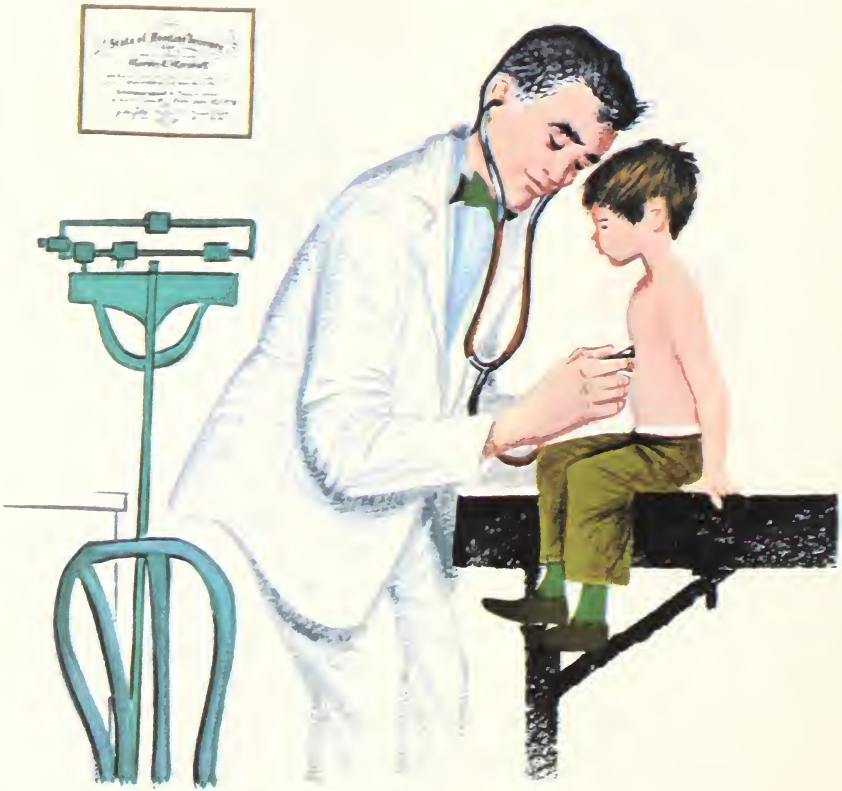
**Developing the Lesson:** Have a brief discussion with the children about their visits to the doctor.

- *What does the doctor use to help him when he examines you?* (Scale, flashlight, etc.)
- *What does the doctor use when he wants to listen to the sounds in your body?* (Introduce the word *stethoscope.*)

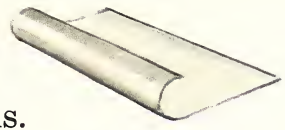
The stethoscope enables the doctor to hear the heart more plainly because it carries the sound of the heartbeat directly to his ears.

# What does the doctor hear?
# What helps the doctor hear?

*The stethoscope is a scientific instrument that extends the doctor's range of hearing. Children should understand that it is important for him to listen to their heartbeats. Point out that the doctor's training and experience enable him to know what is wrong if the heartbeat does not sound the way it should to him.*



Do this.



Now do this.

What do you hear?



A rolled-up piece of paper or a hollow cardboard tube makes a rough equivalent of a stethoscope.

Have the children listen to each other's heartbeats. Then, have the children touch their toes five times.

Have the children listen again to each other's heartbeats.

- *Which time was the heartbeat faster?*

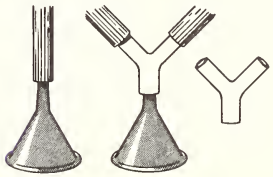
Another representation of a stethoscope can be made by using a funnel and a short length of hose.

**Follow-Up:**

- *What helps the doctor to hear your heartbeat?*
- *How does the stethoscope help him?* (It makes the sounds louder.)

○ **ADDITIONAL ACTIVITIES:**

Borrow a stethoscope from a nurse or a doctor. Let the children listen to each other's heartbeats.



TEACHING SUGGESTIONS

**LESSON:** Where is it louder?

**Learnings to Be Developed:** A funnel helps to make a sound louder.

**Developing the Lesson:** Start the lesson by having the children read the activity on page 96. Have all the children listen to a loud-ticking watch that is placed on a wooden table. Then have each child hold a paper funnel against his ear as in the picture on page 96.

- *Which time was the sound of the watch louder?* (With the funnel.)
- *Why do you think it was louder when you used the funnel?* (The funnel helped to carry the sound of the watch directly to the children's ears. Also, the funnel helped to screen out other sounds.)

**Follow-Up:**

- *Why does a funnel help you to hear sounds better?*

**ADDITIONAL ACTIVITIES:**

The children can make a milk-carton telephone. Cut off the tops of two milk cartons. Stretch a long piece of string from one milk carton to the other, knotting the string on the inside of each carton.

# Where Is It Louder?

Listen to a watch this way.

Now listen to a watch this way.
Do you hear it better?

*Bring in an audiometer if possible. Point out that it is a measuring instrument. It shows exactly how loud a sound has to be for you to hear it.*

# Testing Your Hearing

This machine can test how well you hear.

You listen to the sound it makes.

You tell when you cannot hear the sound.

Some children do not hear well. What can they do?



## TEACHING SUGGESTIONS

● **LESSON:** How can your hearing be tested?

**Learnings to Be Developed:**

Your ears enable you to hear sounds.

Instruments are used to test how well you hear.

There are ways to help you if you do not hear well.

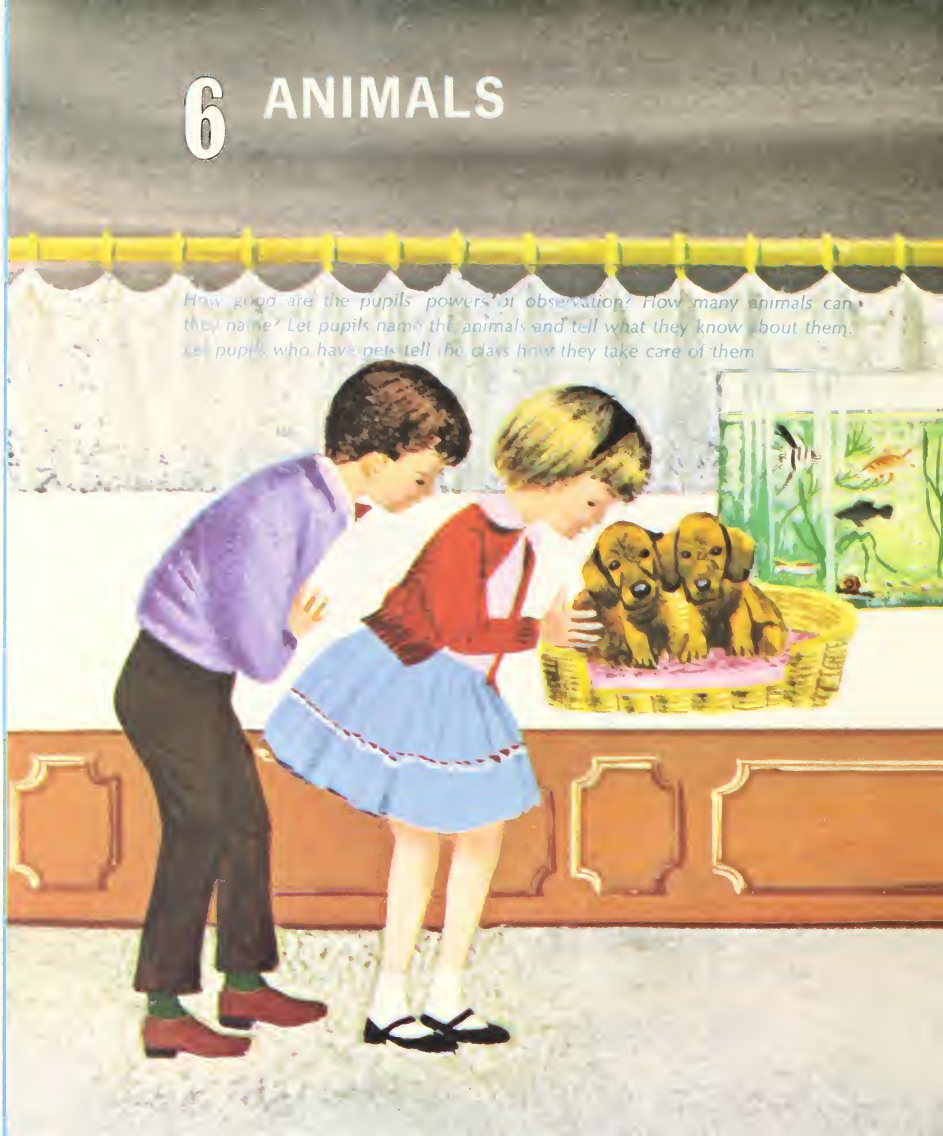
**Developing the Lesson:** By this time of year, the children will probably have been given an audiometer test. Ask the children to describe the sounds they heard through the earphones and how the sounds varied in pitch (*pitch* is how high or low a sound is).

Explain to the class that some people who do not hear well can hear better if they wear a hearing aid. This is a good time to remove any stigma attached to any child who, because of a hearing impediment is required to wear a hearing aid.

Stimulate a discussion of ways in which children can protect their sense of hearing.

- *How can you take good care of your ears?* (Keep sharp objects away from ears; blow nose gently; see a doctor if you have an earache.)

# 6 ANIMALS



How good are the pupils' powers of observation? How many animals can they name? Let pupils name the animals and tell what they know about them. Let pupils who have pets tell the class how they take care of them.

## KEY CONCEPTS

**Key Concept 1.** Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

**Key Concept 2.** Lawful change is characteristic of events in the natural environment; although living things tend to produce living things like themselves, over millions of years the earth and living things on the earth have changed, and diversified forms of life have evolved.

**Key Concept 8.** There is a relationship between structure and function; the structure of parts of living organisms determines the function of those parts.

**CONCEPTS:**

1. There are many kinds of animals.
2. Many different kinds of animals can be seen in a pet shop.
3. Animals are alike in some ways and different in others.
4. Animals can be grouped according to important ways in which they are alike.
5. In one of the large groups, the animals all have jointed legs and hard coverings over their soft bodies.

What animals do you see?

*Other concepts appear under "Learnings to Be Developed" in each lesson found in the Teaching Suggestions.*



6. In another large group, the animals all have backbones. (Man is in this group.)
7. Animals need food, water, and air to live.
8. Animals have babies. Mammals give milk for their young.
9. Birds are animals with feathers. Each type of bird is different from other birds.
10. Bills of birds are adapted for different uses.
11. Some birds migrate when seasons change.
12. Birds make different kinds of nests.
13. Baby birds hatch from eggs after they are developed.
14. Animals have protective coloration.
15. Animals have homes.
16. Different animals build different kinds of homes.
17. Animals build the kind of home that is best for them.
18. Animals use different kinds of materials to build their homes.

**PROCESSES:**

- Observing—Pages 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114.
- Comparing—100, 105, 106, 107, 108, 110, 111, 112, 113, 114.
- Classifying—100.
- Explaining—104.
- Demonstrating—113.

TEACHING SUGGESTIONS

**LESSON:** How are animals alike and different?

**Learnings to Be Developed:**

Animals can be grouped according to important ways in which they are alike.

In one of the large groups, the animals all have jointed legs and hard coverings over their soft bodies.

In another large group, the animals all have backbones. (Man is in this group.)

**Background:** Pages 100 and 101 were designed to introduce the concept of classification. The biologist classifies animals on the basis of relationships that seem important.

The animals on page 100 all have jointed legs and hard coverings over their soft bodies. Try to have the children guess these qualities of the animals on this page.

- *Does the body of a crayfish feel hard or soft when you touch it?*
- *What helps the grasshopper to move so quickly?*
- *How are the legs of these animals alike?*
- *How are the legs of these animals different?*

feelers and the number of parts to the animals bodies.

Here are some animals.
How are they alike?
How are they different?

Insect

Crayfish

Spider

*Have the pupils compare as many features as possible.*

These animals are alike in some ways.
How are they alike?

Fish

Frog

Snake

Cat

Bird



All the animals on page 101 are *vertebrates*. That is, they all have backbones. Try to elicit this fact from the children.

- *What do you feel when you pet a kitten along its back?* (Backbone.)
- *What do you take out of a fish before you eat it?* (Backbone and bones.)

List on the chalkboard the important characteristics of both animal groups. Ask the pupils to name other animals belonging to these groups. Have them test each animal against the characteristics listed on the chalkboard. If the pupils do not think of it, point out that man has a backbone too, and therefore man belongs to the group on page 101.

**Follow-Up:** Make a chart to show how some animals are alike and some animals are different from one another.

**ADDITIONAL ACTIVITIES:**

Try to obtain skeletons of some of the vertebrates shown on page 101. Have the children compare the skeletal structures of these animals.

TEACHING SUGGESTIONS

**LESSON:** What do animals need to live?

**Learnings to Be Developed:** Animals need food, water, and air to live.

**Developing the Lesson:** Have each child compare himself to a book.

- *What can you do that a book cannot do?* (Walk, think, grow, breathe, etc.)
- *Does a book ever get hungry or thirsty?*
- *Do you ever get hungry or thirsty?*
- *What two things do you need that a book does not need?* (Food and water.)
- *Could you stay locked in a closet over the weekend like a library book? Why not?* (Animals need air.)

Ask the class to read page 102.

# What Animals Need

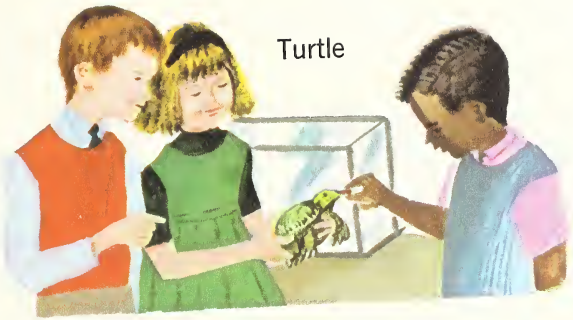
These animals need food and water and air.

Horse

Penguin

Lion

All animals need food.
All animals need water.
All animals need air.



Turtle

You can learn about animals by taking care of them.

Maybe you can get an animal for your classroom.

First find out how to take care of it.

What will it eat?

Will the classroom be warm enough?

Guinea pig



Children learn a great deal about animals by caring for them and observing what the animals do. If animals are permitted in your school, the children can select for the classroom one of the following animals: frog, guinea pig, rabbit, turtle, goldfish, chameleon, non-poisonous snake, tadpole, or parakeet.

The children should learn to take some responsibility for the animal's care, and the teacher should encourage the proper attitudes toward the animal. Improper handling of the animal often results unless there is a real concern for the animal's welfare.

In planning for the care of an animal, the children should discuss what is involved in its care, and research should be done in advance of securing it. The children should be clear about the following: What kind of home does the animal require? What does it eat? How will it be taken care of over the weekends or over holidays? What must be done in providing food and water, and in keeping the cage clean?

TEACHING SUGGESTIONS

● **LESSON:** How are most baby animals cared for?

**Learnings to Be Developed:** Most baby animals are cared for by their mothers.

**Developing the Lesson:** If possible, the children should watch mother animals caring for their young. Have the children relate any of their experiences watching mother animals caring for young.

Continue the discussion by talking about the children's own experiences with baby animals.

- *Has anyone here ever cared for a baby animal?*
- *What did you do?* (The most common experience, of course, is feeding.)

Discuss with the children how their own mothers care for their younger brothers and sisters.

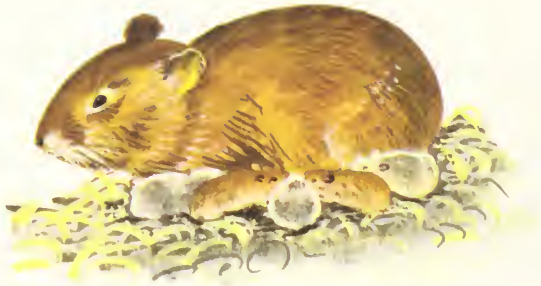
**Follow-Up:**

- *How do animal parents care for their baby animals?*

A mother guinea pig

A father guinea pig

This mother has babies.
The babies will get milk from the mother.

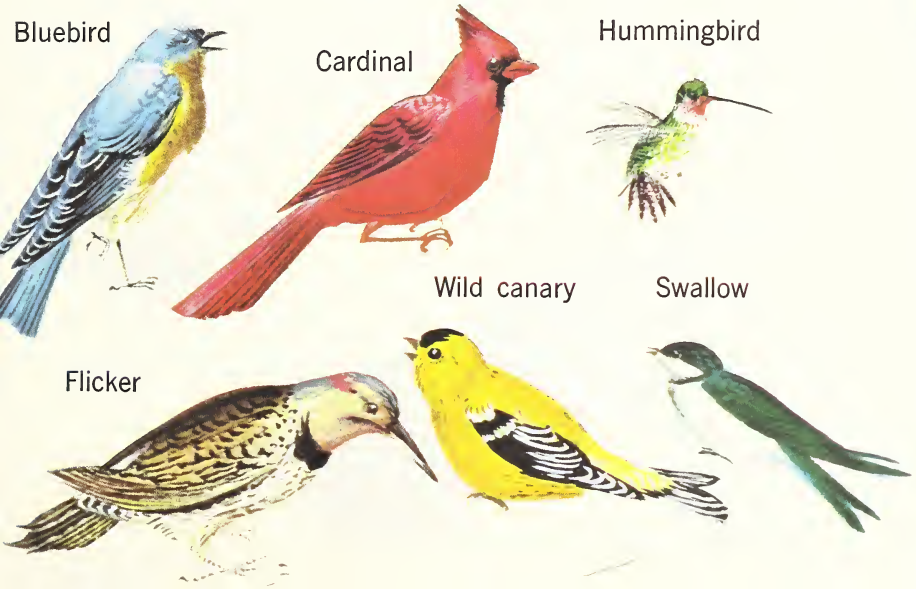


What other animals can have babies?

# Birds

Birds are animals with feathers.
There are many different birds.

You can know birds by their color.
You can know birds by their size.
You can know birds by the way they fly.
You can also know birds by the way they sing.




● **LESSON:** How can we identify birds?

**Learnings to Be Developed:**

Birds are animals with wings.

There are many different kinds of birds. Each kind has a different name.

Different kinds of birds live in different places.

You can identify birds by their color, size, song, and the way they fly.

**Developing the Lesson:** If weather permits, walk through a park with the children, looking for birds. Try to note different activities of the birds, such as bathing, perching, flying, and nest-building. (Do not expect the children to identify all of the birds.)

Discuss how the birds shown on page 105 are different. (They have different shapes or outlines; they are different in size; they have different colorings and markings.)

○ **ADDITIONAL ACTIVITIES:**

Play records of bird calls.

Get a bird feather. Use a magnifying glass to examine the feather. Pour water on the feather to see how it sheds water.

TEACHING SUGGESTIONS

**LESSON:** How does a bird use its bill to get food?

**Learnings to Be Developed:**

Birds use their bills to get food.

Anatomical structures in animals relate to function.

Differently shaped bills do different kinds of work.

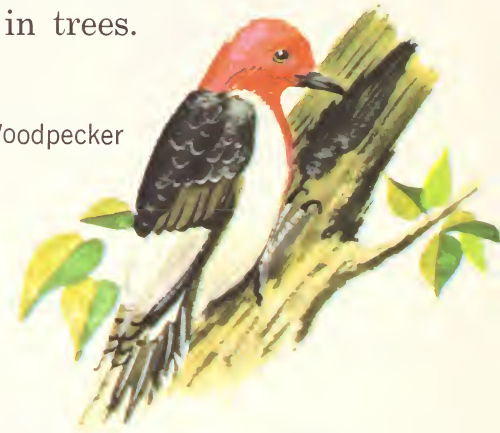
**Developing the Lesson:** Review with the children the various functions of their own teeth. (The front teeth cut and tear the food; the back teeth grind and chew the food.)

Have the children look at the pictures on page 106. It will now be easier for the children to comprehend why differently shaped bills help to serve different functions in getting food for different birds.

The shape and size of the bill helps to suggest what the bird eats. Birds such as woodpeckers, have long bills, eat flies and other insects. Birds such as sparrows, having short bills, eat seeds. Birds such as hawks, having strong hooked bills for tearing, eat small animals.

Birds have different kinds of bills.

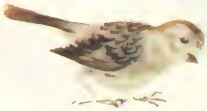
This bird has a sharp bill. It can find insects in trees.



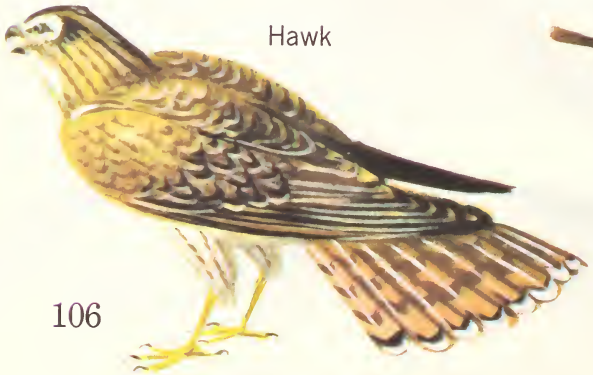
Woodpecker

What can these birds do with their bills?

Sparrow



Hawk



Some birds fly away when it gets cold. They fly far away. Sometimes they fly many miles over water.

The birds come back when it gets warmer. We do not know how they find their way.

Are some birds flying away now where you live?

Are some birds coming back?

**Background:** The phenomenon of bird *migration* is still an unsolved subject. Scientists have many theories as to why this phenomenon occurs, but to this day no one theory fully explains all the reasons for migration.

Many birds fly from continent to continent, covering up to 15,000 miles or more on a round trip. How and why they do so, no one knows. Change of seasons and changing food supply may be two reasons, but this theory is not sufficient because some birds do not migrate.

How do they find where they are going and how do they find their way back? Some warblers use stars as a guide, according to an article by E. B. F. Sauer, "Celestial Navigation by Birds," which appeared in the August, 1958, issue of *Scientific American*.

Additional information has been discovered: Small birds tend to migrate at night so as to be safe from larger birds. They stop to eat in the morning and rest during the day. Some birds fly as far as eighty to ninety miles a day. Some birds, like ducks, fly forty to fifty miles per hour. Swifts can fly as fast as one hundred miles per hour.

TEACHING SUGGESTIONS

● **LESSON:** How are birds' nests different from one another?

**Learnings to Be Developed:**

Birds use different kinds of materials to build their nests.

Different birds build different kinds of nests.

Some nests look very hard to build.

**Developing the Lesson:** Tell the children the names of the birds on page 108 and have the children note the different sizes and shapes of the birds' nests.

Orioles live near houses and build their nests in trees. They use bits of string or cotton, or pieces of cloth, for building a nest.

The nest of the swift is made of coarse sticks glued against a wall or chimney. The warbler uses mud to build its nest.

Help the children to speculate how these birds are able to build nests like these. Help them to see that animals frequently are endowed in some ways with remarkable ability.

Birds make nests in the spring.
Birds make their nests in different places.
Birds make their nests of different things.

Swift

This bird makes a nest of sticks.

Meadowlark

This bird makes a nest of grass and weeds.

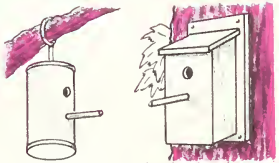
Oriole

This bird makes a nest of string and bits of cloth.

*Encourage children to build bird-feeding stations at home.*

The mother bird lays eggs in the nest. She sits on them. She keeps the eggs warm.

The father bird brings food to the mother bird.



*Wren house* *Chickadee house*



Discuss the possible reasons why birds build their nests at certain places. (The woodpecker eats insects found under the bark of trees. The kingfisher eats frogs and small fish. The meadow lark eats seeds and insects. The goldfinch eats seeds and insects.) They build nests where food is readily available. Other reasons may be that the young are protected, or that the materials for nest building are more plentiful.

**LESSON:** Why do birds build nests?

**Learnings to Be Developed:**

Birds build nests in which to lay their eggs.

Birds build nests for their babies, but the parent birds do not live in the nests themselves, except when they are rearing their young.

**Developing the Lesson:** Begin the lesson with a question:

- *Why do birds build nests?* (The tendency is for the children to say that birds live in nests. Birds build a nest solely to raise young birds. The baby birds live in the nest until they are big enough to take care of themselves. Adult birds do not live in a nest, except when they are rearing young birds.)

TEACHING SUGGESTIONS

● **LESSON:** Where does a bird develop?

**Learnings to Be Developed:** A bird develops inside an egg.

**Developing the Lesson:** Break an egg in a dish.

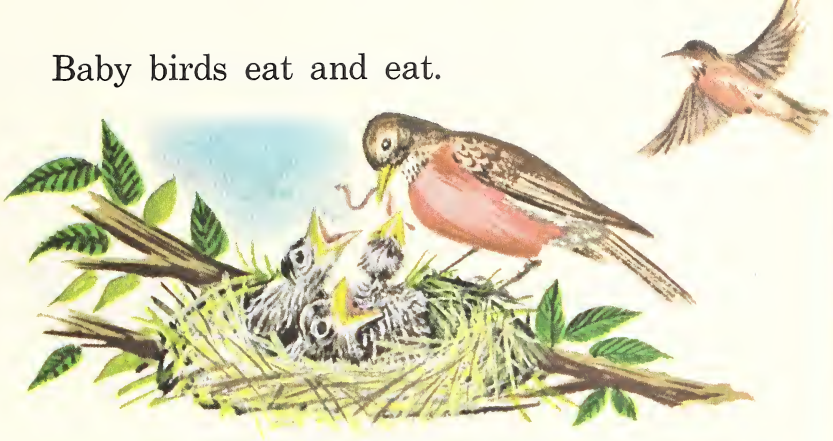
- *Which part of the egg would have become the chicken?* (The embryo is actually the small white spot attached to the yellow yolk. The yolk provides the food for the growing bird. The "white" of the egg provides protection.)
- *How does the bird get out of the egg?* (It chips away the shell with its bill.)
- *How many eggs does a bird lay?* (It varies with the species.)
- *How long do you think it takes for a robin's eggs to hatch?* (About two weeks.)
- *Do baby birds look like their parents?* (Not at first.)

**Follow-Up:**

- *Where does the baby bird grow?*
- *What part of the egg is the food?*

A baby bird grows inside the egg.
It grows bigger and bigger.
Then it comes out of the egg.

Baby birds eat and eat.



The baby birds grow very fast. Their wings get strong. Then the birds fly away.

The mother bird and the father bird find food for them.

Here are some things baby birds eat.

**LESSON:** Do birds take care of their young?

**Learnings to Be Developed:** Many birds care for their young.

**Developing the Lesson:**

- *How do the mother and father birds care for their babies?* (Feed them; protect them from predators.)

Have the children identify the various things that the babies eat. (Worms and insects.)

Stress that the period of dependency for young birds is very short compared to that of humans. The birds remain in their nests only until their wings are strong enough to enable the birds to fly away.

**ADDITIONAL ACTIVITIES:**

The children can make a feeder. Get two wooden bowls. One about 10 inches in diameter, the other about 6 inches in diameter. A dowel or a piece of broomstick, about 1 inch in diameter and about 6 inches long, is needed. Invert the larger bowl over one end of the dowel and nail it in place. Turn over and nail smaller bowl to other end of the dowel. Insert a screw eye into bottom of the larger bowl and tie feeder to a limb of a tree with a rope.

## TEACHING SUGGESTIONS

**LESSON:** How does a bird's coloring help to protect the bird?

**Learnings to Be Developed:** Some birds have coloring that helps to protect them.

**Developing the Lesson:** Have the children tell why a teacher writes with white chalk on the chalkboard. (It is easy to see.)

- *What color chalk might be hard to see on the chalkboard?*
- *Is a light-colored shirt or a dark-colored shirt easier to see at night?*
- *Would it be better for you to wear a light-colored shirt or a dark-colored shirt when walking at night?*

Place a one dollar bill on a bright red piece of paper and another one dollar bill on a dark green piece of paper.

- *Which dollar bill is harder to see?*

Have the children read and follow the instructions on page 112. Supply the necessary paper and crayons. Have the children place their birds directly onto page 112 and answer the last question on that page.

Some birds are hard to see.
You can find out why.
Make some birds out of paper.

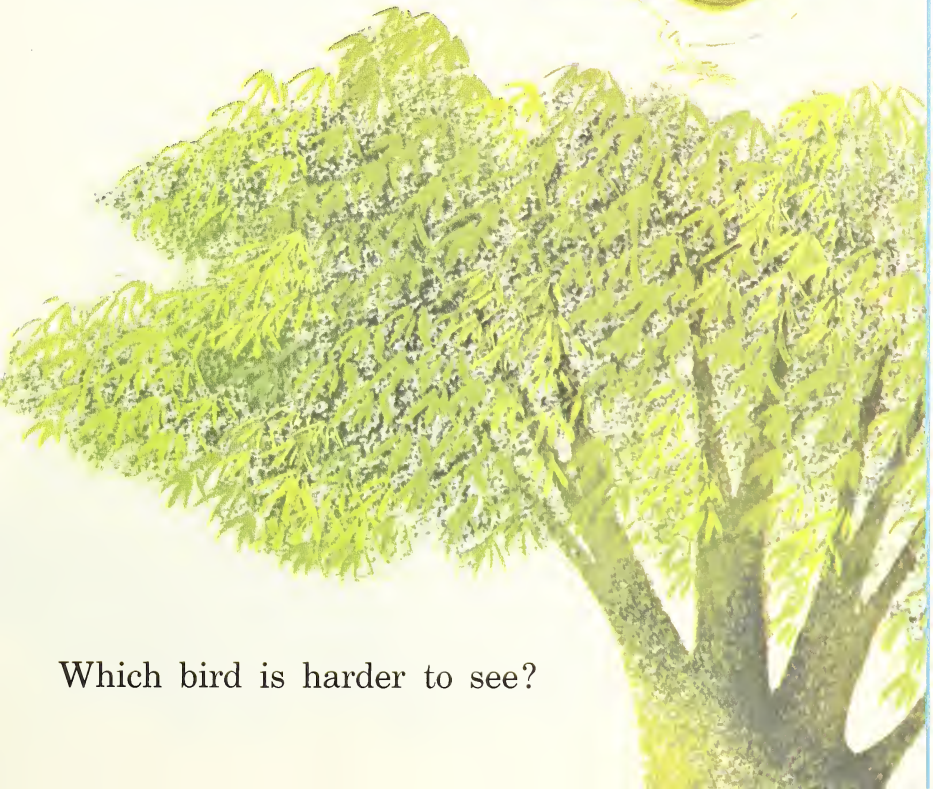
Color the birds this way.

Put the birds in this grass.
Which bird is harder to see?

Make some birds out of paper.

Color the birds this way.

Put the birds in this tree.



Which bird is harder to see?

Read page 113 and follow the same procedure.

**Follow-Up:**

- *Why are some birds harder to see than others?*
- *What other animals have colors that protect them?* (Rabbit, deer.)
- *How do these colors help the animals to live?*

**ADDITIONAL ACTIVITIES:**

Find pictures of various animals such as a fawn, frog, caterpillar, showing how the animals' coloring helps to camouflage them.

## TEACHING SUGGESTIONS

● **LESSON:** How does the coloring of the parent birds help to protect the young?

**Learnings to Be Developed:** Protective coloration helps birds to keep their young safe.

**Developing the Lesson:** Have the children read page 114.

- *Do the father and mother bird look alike?*
- *How are they different?* (The male usually has more brilliant plumage.)
- *Why is the mother bird harder to see?* (She blends in with the tall grass.)
- *Why do you think it is safer for the mother bird to sit on the eggs?* (She is less likely to be attacked by predators since her coloring helps her to blend in with her surroundings. She is therefore able to sit on the eggs until they hatch. The father bird would be easily seen because of his brilliant plumage.)

**Follow-Up:**

- *Why is it safer for the mother, rather than the father, to sit on the eggs?*

The mother bird sits on the eggs.

The father bird does not sit on the eggs.

Which bird is harder to see?

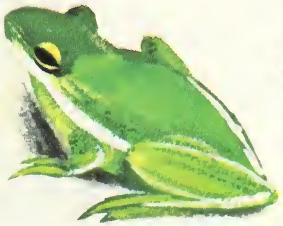
A mother bird A father bird

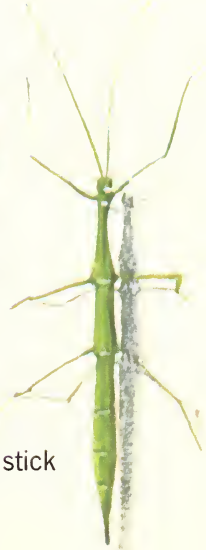
These animals are hard to see.
Can you tell why?

Polar bear

Sea horse

Tree frog





Walking stick

**LESSON:** Why are certain animals sometimes hard to see?

**Learnings to Be Developed:** Many animals have protective coloring to help them survive.

**Developing the Lesson:** Have the children identify the animals on page 115.

- *What color is the polar bear?*
- *What color is the ice?*
- *Does the bear's coloring make it hard for its enemies to see the bear?*

The walking stick lives in the grass. When it remains stationary, the walking stick is hard to see; the walking stick is hard to distinguish from a blade of grass.

- *How does the color of the walking stick help the walking stick to catch insects?*

**Follow-Up:**

- *How do the colors of some animals help them?*

TEACHING SUGGESTIONS

● **LESSON:** In what kind of homes do animals live?

**Learnings to Be Developed:**

Different animals build different kinds of homes.

Animals build the kind of home that is best for them.

Animals use different kinds of materials to build their homes.

**Developing the Lesson:** Have the children read page 116.

- *What kind of animal is shown in the first picture?*
- *Where is its home?* (In a burrow in the ground.)
- *Why do you think it builds its home underground?* (It can hide from its enemies; it can sleep all winter, and be protected from cold and snow. The burrow is also a safe place in which to raise babies.)

● **LESSON:** How do ants live?

**Learnings to Be Developed:**

Ants are animals. They need food, air, and water.

Many ants live together in each ant hill.

The queen is bigger than the other ants.

# Animal Homes

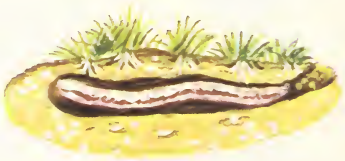
Animals need a safe place to live.

Animals live where they can find food.

Here are some animals and their homes.

Woodchuck

Earthworm



Squirrel

Beaver

# Ants

Ants are animals.

Ants do not live alone. They live with many other ants. Ants live in an ant hill.

Different ants do different kinds of work. (Some dig tunnels, some feed others, and some stand guard.)

**Developing the Lesson:**

- *How are ants like other animals?* (They need water, food, air.)
- *How are ants different from many kinds of animals?* (Ants live together in colonies.)
- *Where do ants live?* (In an ant hill; but some species live in other places.)
- *How do ants get food?* (Ask the children to describe how they have seen ants carrying off large pieces of food on their backs.)
- *If you take some ants from an ant hill, what must you be sure to do if they are to stay alive?* (You must provide a similar home. You must know how to take care of them.)

Soil that is taken from near the ant colony should be put into the jar, as the ants will not live in different soil. You must dig into the center of the ant hill with a large spoon. Use the spoon to pick up about eight to ten ants. Then dig a little deeper and take up several more ants. Repeat. You should secure different ants, such as guards and workers; also some eggs. Carefully put these into the jar.

MATERIALS CHECKLIST

| | MATERIALS CHECKLIST | QUANTITY | DATE NEEDED | SOURCE |
|---|---|---|---|---|
| Unit 1 | basin<br>pyrex jar<br>glass bowl<br>cardboard (large sheet)<br>3 paper cups<br>paper plate | | | |
| Unit 2 | grapes<br>plastic squeeze tube | | | |
| Unit 3 | triangular piece of wood<br>horseshoe magnet | | | |

This is a worker ant.

This is a queen ant.

The queen ant is bigger than other ants. She lays eggs.

You can find out more about ants.

Get some ants and do this.

In this lesson the child uses simple research skills — collecting data and observing. These skills are basic to concept formation.

Use fine cheesecloth. Let your pupils use magnifying glasses in making their observations. Have them report their observations to the class. Record the observation on experience charts.

Ants need food. What will you give them to eat? How will they get water?

## Vocabulary and Sentence Structure

The Macmillan Science Series is designed to present meaningful content that is interesting and challenging to pupils. The authors have recognized the reading problem involved in presenting worth-while content, and have met this problem by (1) using a carrying vocabulary of words commonly found in readers, and (2) carefully presenting selected science words to help the pupil gradually acquire a science reading vocabulary.

In order to establish a workable carrying vocabulary for this book, the authors analyzed the vocabularies of the various basal readers most widely used in first grades. Lists were made of the words commonly found in pre-primers, primers, and first-grade readers.

To keep the increase in difficulty gradual, the authors used a pre-primer carrying vocabulary through the first two units (pages viii–43), a primer carrying vocabulary through the next three units (pages 44–97), and a beginning first-reader carrying vocabulary for the last unit.

A limited number of words, listed on the next page, falls outside the carrying vocabulary. Some of these words are proper names; some are words, like *what* and *how*, which may not have been mastered by the children at this level; some are technical words, such as *insect*, *germs*, *magnet*, which are necessary for the development of the science-health concepts. Many of these words are interesting to the children so that they are easily remembered.

Most of the words that fall outside the carrying vocabulary need not be taught for mastery. But these words should be practiced enough so that children will remember them. These words are essential for reading or writing activities based on science, health, and safety.

In addition to carefully controlling the vocabulary, the authors have controlled sentence structure. The sentences, at first short and very simple, gradually increase in length and variety.

One additional feature of the reading plan should be noted. The authors have included in the text certain parts which pupils should not be required to read, but which may offer a challenge to the better readers. Thus there are picture labels which are not necessary to an understanding of the pictures or of the text. But the pupil can easily "read" many of these words by naming the items in the accompanying pictures, and the better readers will acquire many of these words permanently. The end of the last unit is graded in difficulty for fast readers. Through these built-in devices, the text enables the teacher to provide for individual differences.



MATERIALS CHECKLIST

| | | | | |
|---|---|---|---|---|
| Unit 3 (cont.) | two bar magnets<br>2 long needles<br>wire clippers<br>cork<br>compass | | | |
| Unit 4 | chicken bones | | | |
| Unit 5 | prism<br>large piece of cardboard<br>razor blade<br>tape<br>mirror | | | |

MATERIALS CHECKLIST

| MATERIALS CHECKLIST | QUANTITY | DATE NEEDED | SOURCE |
|---|---|---|---|
| Unit 5 (cont.) | blue cellophane paper<br>red cellophane paper<br>green cellophane paper<br>triangle | | |
| Unit 6 | light green crayon<br>dark green crayon<br>red crayon<br>soil<br>cheesecloth<br>bread crumbs<br>ants | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| viii. | changes | 34. | germs | 65. | | 94. | |
| 1. | | 35. | different | 66. | | 95. | |
| 2. | | 36. | | 67. | X-ray | 96. | |
| 3. | Bill | 37. | | 68. | breastbone | 97. | |
| 4. | | 38. | | 69. | Sally | 98. | |
| 5. | | 39. | squeeze | 70. | | 99. | |
| 6. | | 40. | | 71. | | 100. | alike |
| 7. | what | 41. | | 72. | Ted | | insect |
| 8. | | 42. | | | Judy | | crayfish |
| 9. | | 43. | | 73. | David | 101. | snake |
| 10. | | 44. | | | Fred | 102. | penguin |
| 11. | | 45. | | 74. | Larry | 103. | classroom |
| 12. | Tom | 46. | Jim | | Peggy | | guinea pig |
| 13. | | | Alice | 75. | | 104. | |
| 14. | | 47. | | 76. | | 105. | cardinal |
| 15. | | 48. | Anne | 77. | bedtime | | flicker |
| 16. | | | Peter | 78. | Ben | | hummingbird |
| 17. | | | seesaw | | television | | wild canary |
| 18. | how | 49. | | 79. | | | swallow |
| 19. | crystals | 50. | magnet | 80. | Nancy | 106. | hawk |
| 20. | | 51. | | 81. | | 107. | |
| 21. | Bob | 52. | | 82. | Dick | 108. | swift |
| 22. | | 53. | | 83. | | | oriole |
| 23. | | 54. | | 84. | | 109. | |
| 24. | | 55. | | 85. | | 110. | |
| 25. | | 56. | | 86. | rainbow | 111. | |
| 26. | | 57. | | 87. | | 112. | |
| 27. | | 58. | | 88. | | 113. | |
| 28. | Mary | 59. | | 89. | Tim | 114. | |
| 29. | Jack | 60. | compass | | Jane | 115. | walking stick |
| 30. | | 61. | | 90. | traffic | | polar bear |
| 31. | | 62. | | 91. | | 116. | beaver |
| 32. | | 63. | Don | 92. | | | earthworm |
| 33. | | 64. | | 93. | | | woodchuck |

# TEACHERS' GUIDE FOR *BOOK 1*

# TEACHERS' GUIDE FOR *BOOK 1*

## Science for Tomorrow's World

BARNARD
STENDLER
SPOCK
MOFFITT

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In most elementary schools, it is the classroom teacher rather than a specialist in science education who teaches science. Thus, the classroom teacher must have some knowledge of the subject matter of science as well as an awareness of how children learn. The Teachers' Guide of *Science for Tomorrow's World* provides help in both of these areas. We include supportive factual information to strengthen what the teacher already knows about science, as well as teaching suggestions based on the present knowledge of how children learn.

To be truly effective as a teacher of science, the teacher must have an understanding of what science *is* and what a scientist *does*. We often hear that the American child of today is growing up in a scientific age. What does this really mean? What exactly *is* sci-

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hel Carson
1964) United States
hel Carson was born and grew up
small town of Springdale, Pennsyl
a. There, and in the surrounding
ntryside, her mother taught her to
the world of living plants and ani-
s. She learned from her mother that
ery living thing has its place in nature
d performs some useful function. It
ly mankind that thinks of some flowers
s "weeds," or insects as "pests." In
nature there are no "weeds," no insect
"pests."
When Rachel Carson grew up she be-
came a biologist. In her studies she
learned that in all of nature there is a
balance among all living things. This
balance prevents plants and animals
from doing harm to man, to the country-
side, or to themselves. When the bal-
ance of nature has been upset for some
reason, plagues and epidemics occur.
After college, Rachel Carson went to
work in Washington, D.C., for the Fish
and Wildlife Service. In her spare time
she wrote books about the beauty and
wonders of nature. These books—Under
the Sea Wind, The Sea Around Us, and The
Edge of the Sea—made her famous
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ence? The answer to this last question will determine the teacher's approach and orientation to every lesson presented. To help the teacher gain a fuller understanding of the climate of our scientific age, we begin the Teachers' Guide with a discussion of the meaning of science and the work of the scientist.

## SCIENCE AND THE SCIENTIST

Science is the study of natural phenomena; it concerns itself with describing such phenomena and attempting to explain them through laws that constantly can be tested and corrected against consequences in experience. These scientific laws are then fitted into a working model of the universe—a model that may be in the form of an idea, a diagram, or a construction (Book 6, p. 145). Often, scientists must do many experiments before a working model can be developed. Often, too, many experiments and much theorizing are done after the model is developed, in order to determine whether or not the model is accurate. An accurate working model may be highly useful in predicting future events. With a working model of the solar system, for example, it is possible to make predictions about when eclipses will occur, when Mars will be closest to the earth, when tides will be high, and where the earth will be in relation to other planets at any given time in the future. In some instances, a working model also helps to control man-made or natural phenomena. A model of motion that approximates natural motion is indispensable in controlling man-made motions such as those of a primitive ox-cart or a modern space satellite. This is not to imply that science is concerned with prediction and control for practical reasons only. Such concern has grown out of man's need to dispel uncertainty, to know the world in which he lives.

In constructing a foundation for a model of reality, the scientist uses ideas of time, space, matter, causality, and number. In each of these areas, the scientist believes there is order; things do not happen in a haphazard fashion in the world of nature, but in a logical, noncontradictory manner. Thus, no matter what year, no matter what season, the sun always appears at dawn in the east. No matter what kind of projectile is launched from the earth into space, the projectile has two kinds of motion—a forward motion in the direction in which it was launched and a downward motion in the direction of the center of the earth.

From the dawn of history, man has sought to explain what he observed and then to use his explanations to predict future events. Even long ago, scientists believe, man was able to predict certain natural phenomena. They believe that an ancient people at Stonehenge, England, studied the movements of earth and sun and were able to place great rocks in such a fashion as to predict the beginning and ending of seasons and eclipses. We can find countless other examples to show that the order in the universe became evident to man's intelligence and that he used the test of prediction to prove the existence of that order. For example, at Stonehenge, it is believed that if ancient man's notions about movements of sun and earth were wrong, the sun would not have been seen rising over a particular stone on a particular day of the year; thus, the concept would have to have been changed accordingly. Sometimes when ancient man was unable to find an explanation for natural phenomena, he resorted to magic. Through magic, he thought himself able to explain a particular event, not by recourse to natural laws, but by the invention of uncontrollable "somethings" that he believed might yield to magical rites.

Why did man gradually give up magic and turn more and more to a search for natural laws? Psychologists find the explanation in the part of man's biological inheritance that is intelligence—a form of mental adaptation that causes man to seek to deal effectively with his environment. This basic need produces a tendency to give up explanations that do not conform to reality. Reality comes to be not what one perceives with the senses, but rather the product of trans-

formations that one performs upon data in the mind. A distant elm may appear to be smaller than a nearby birch sapling, but the mind puts each tree in proper spatial perspective. It may have seemed to ancient man that the sun traveled around the earth, but such a concept of the solar system is not consistent with all the known facts, and so man eventually constructed a more realistic concept of the solar system.

It is evident that science involves more than just the accumulation of new facts about the universe. Galileo's "facts" about motion are already known to anyone who has rolled an object down an inclined plane or thrown an object from a moving vehicle. All the facts needed to derive the concept of gravitation were known to man long before Newton. The great forward leaps in science have often come about not because man discovered new facts about the universe, but because a great scientific mind saw those same facts in a new framework. The search for new facts goes on continuously in scientific laboratories, but the major breakthroughs take place inside the minds of scientists themselves.

How do these breakthroughs occur? What does man look for to make the world more intelligible? Two guiding principles stand out: Man looks for *unity*, and he looks for *simplicity*.

To look for unity means to look for likenesses, often in unexpected places. It means, for example, seeing that the model of the solar system might also serve as a model for the atom. It means seeing similarities among the ant, the fish, the mouse, and man. For convenience, man may divide science into the study of the physical and the biological—the living and nonliving. But man searches for more than merely a similarity between any two related facts; he searches for a law that will explain *all* such related facts, and thus he strives toward unity.

The second guiding principle in man's striving to make the world more intelligible is that of simplicity. Man seeks the basic units—ultimate and fundamental units—out of which more complex matter is built. The discovery of the cell and the discovery of the atom were two milestones in man's striving toward simplicity. Present-day explorations of molecular activity in the cell lead further in the direction of unity and simplicity; eventually, the activities of all living things may be explained in terms of atoms.

In preparing *Science for Tomorrow's World*, the authors have been guided by a modern viewpoint of science. We have constantly asked ourselves what this modern viewpoint implies for science education in elementary schools. We turn now to a consideration of those implications which have guided our thinking in the planning and developing of this series.

## A PHILOSOPHY OF SCIENCE EDUCATION

Three basic principles form the foundation of our approach to science education. First, we affirm our faith in the *natural curiosity of the child as a powerful motivating tool in acquiring science knowledge*. We believe that this curiosity can be kept at a high level, not necessarily by the use of bizarre or dramatic science activities, but by making explicit to the child the difference between his own view of reality and reality as it actually exists—as well as man can conceive of it. The child brings with him to the classroom a tremendous body of cognitive structures that he uses to explain the universe. The problem in teaching science to children is not that the child does not have explanations for natural phenomena; it is rather that his explanations are often either half-correct or wholly incorrect. Yet, if we can assume on the part of the child a basic urge to deal effectively with his environment, when he becomes aware of the discrepancy between what he believes and what is reality, we can then conclude that he will be more ready to apply the use of logic in his thinking. Here, both deductive and inductive (discovery) processes are invaluable. Some key concepts can best be taught by direct presentation that

is followed by applications of the key concepts to a wide variety of data. Thinking can be stimulated when the teacher says, for example, "How does what we have learned about sound apply to a mammal such as the bat? How can the bat's sense of hearing help the bat to know when an object is near?"

The discovery method is most effective when reserved for the induction of certain general laws. For example, in the study of animal behavior, children can discover for themselves some of the relationships between temperature and behavior. They can observe what happens to the behavior of a goldfish when the temperature of the water in the aquarium is lowered; they can note the movement of insects that have been placed in a box that is heated at one end. In the study of light, however, we cannot expect young pupils to use the inductive process to arrive successfully at the wave theory of light. Thus, deductive and inductive methods of presenting material have been used both selectively and realistically in *Science for Tomorrow's World* to achieve a maximum challenge to pupils' intellectual curiosity.

The second basic principle we accept is that *the elementary school child should gradually build a structure of science approximating the structure developed by the scientist.* Sometimes, in an effort to simplify subject matter, teachers have introduced erroneous concepts on the supposition that these concepts were easier for the child to understand. One such teacher taught that "Some insects lay eggs that hatch into worms"; he did this because he thought that "larvae" was too difficult a word to introduce to his second-grade class. It is possible, of course, to teach such a concept without actually using the word for the concept. But most important is that *the concept be accurate.* The biologist puts worms into a phylum that is completely separate from the phylum for insects; to say that larvae are "worms" puts a mistaken emphasis upon unimportant similarities in the appearances of the larvae and worms. We believe that a selection of simple but significant concepts can be taught so that even the young child has some exposure to the main ideas that structure a particular field of science. We also believe that children should know of man's long and continuing struggle to structure his knowledge—of the wrong turns he has made at times, and of how difficult it is to give up erroneous concepts even in the face of their inefficacy. Children should know and experience the exploration of the unknown, and they should also attempt to search for coherence in the world around them. Only then will they gain a perspective of science as man's attempt to decipher the code of the universe.

We have emphasized repeatedly man's basic tendency toward equilibrium—his need to resolve cognitive disturbance by accepting those ideas that fit with reality. But, as the history of science so dramatically illustrates, there is at the same time a strong tendency to resist change, to cling to cherished notions. In teaching science, we must not present a picture of the scientist as a kind of superman who readily accepts evidence that contradicts his own way of thinking. Part of the subject matter of science is the history of science; studying the history helps pupils to see the scientist as a human being, one who has had to engage actively in the process of accommodating to new theories—a process as difficult for him as for all other men.

The third principle we accept is that *the acquisition of knowledge can enhance logical thinking when proper attention is paid to processes.* The child becomes more logical in his thinking when he acts upon the data he assimilates, putting two and two together, making analogies by a one-to-one correspondence between parts, seeing the implications of one action upon another, setting up alternative hypotheses ("It's either this or that"), excluding variables that check out to be irrelevant. An important part of the teacher's responsibility in teaching science is to help the child acquire mental processes for transforming data so that

inconsistencies in thinking can be eliminated and reasoning can become more logical.

In teaching elementary school science, much has been made of the scientist's sequential method of searching for truth—of observing, hypothesizing, testing, noting results, drawing conclusions. Each of these activities is an important scientific activity, but note that the scientist does not necessarily proceed step by step from one activity to the next. Thus, observation is part of *every* scientific activity; or, a scientist in the process of testing may observe that a certain phenomenon does not conform to what he thinks ought to be happening, and as a result he may start off on a new and perhaps more important track. The elementary science curriculum ought to describe the scientist's methods. But in order to ferret out contradictions, in order to make children "think like a scientist," we need to emphasize (1) logical thinking, (2) the habit of testing concepts, and (3) the checking of concepts against their consequences in experience. To teach children a pat process is not the answer; we will return to this point later in our discussion.

The child, the structure, the processes—these are the foundation stones of *Science for Tomorrow's World*. While we deal with structure and processes in succeeding sections, there is no separate section on the child; consideration of the learner is woven into every section.

## THE STRUCTURE OF SUBJECT MATTER IN THE ELEMENTARY SCIENCE CURRICULUM

In building a curriculum, the first obvious question that we ask is, "What is considered important for children to learn in the field of science?" With man's knowledge expanding at a fantastic rate, it becomes increasingly necessary to exercise great selectivity in choosing the subject matter that is to be taught to children. For the past ten years, scientists and teachers have been working cooperatively on this problem to produce new science materials for both elementary and secondary schools.

Let us look at an area commonly included in elementary science curricula—Living Things. The majority of pupils in elementary school study living things, but what are the pupils expected to learn? Past curricula taught generalizations such as, "There are many different kinds of animals," "Pets are our animal friends," "Earthworms help to make the soil good for the farmer," "The toad has a tough, dry skin," and "The toad uses its forked tongue to catch insect pests." The difficulty with such facts is that they do not *explain*; they do not help the pupil to grasp the underlying *structure* of the science of living things. Such facts about natural phenomena give descriptions in only a general and superficial way.

In contrast, the present trend in science teaching is to emphasize *key concepts* rather than specific facts. Specific facts are included, but they are seen in relationship to the key concepts. Granted that the toad has a tough, dry skin; the scientist then asks, "What does such a skin *do* for the toad?" In answering this question, the scientist draws upon the key concept of *adaptation*—adaptation being the adjustment that an organism can make to a given set of conditions because the organism possesses certain structures that have survival value and that are passed on to offspring. Such a concept explains many phenomena, from the dry skin of the toad to the claws of the lobster.

Next the scientist asks, "How does it work?" For example, "How is the forked tongue of the toad adapted to the particular diet of the toad?" "What enables the bat to hunt at night?" "How are the eyes of the bat adapted to night flying?" These questions lead to another key concept—the interdependence of structure and function. Again, as with adaptation, this key concept explains many phenomena: The tongue of the toad is uniquely built for "lightning-quick" action in catching and holding onto flying insects; the eyes of nocturnal animals have more rods than do

the eyes of other animals, and so the nocturnal animals are able to use the available light to see in very dark places.

The question of, "How does it work?" in relation to living things eventually brings the investigator to the cell, the basic unit of life. The key concept with which he works here is that the cell can be compared to a factory where raw materials are processed according to chemical instructions inherent in the genes of the cell. The cell's finished products are released into the bloodstream to find their way to the appropriate part of the organism.

From "How does it work?" the scientist goes on to ask, "How did it come about?" The answer to this last question lies in the evolutionary principle that individual differences in the offspring of an animal are passed on to succeeding generations if the differences have survival value. Over millions of years, these differences have led to the enormous diversity of living things in existence today. For example, pupils can trace from a common ancestor the gradual evolution of separate families of dogs and cats. Such an activity is more intellectually exciting than merely learning the fact that "The dog is man's friend."

In the physical sciences also we can find a contrast between the "old" science and the "new" science taught to elementary school children. Let us take, for example, the topic of motion. In many programs, a pupil learns, "A wagon goes faster downhill because of gravity; gravity pulls things toward the center of the earth." But to tell a pupil that gravity makes something accelerate on a decline is only to give a *name* for the phenomenon; it does not really *explain* the phenomenon. For an explanation of any motion, the scientist turns to Newton's three laws. The scientist can predict from one of them that a constant force applied in the direction of the motion will make the object accelerate. This key concept of the effect of a constant force can be used over and over again—to explain why a bicycle will accelerate even though the rider pedals with the same force or why an object falls faster as it nears the ground.

The scientist, using another of Newton's laws, can also predict that for any action in one direction there is an equal and opposite reaction. Again we find that this key concept can be used over and over. The frog is capable of a broad jump of several feet, but only by pushing backward against the mud or sand from which it springs. An inflated balloon released in the air will push forward rapidly as the air inside the balloon jets out, demonstrating the principle of movement of a jet airplane.

## THE CONCEPTUAL FRAMEWORK OF "SCIENCE FOR TOMORROW'S WORLD"

From a study of what scientists themselves consider important in science, the authors of this series have identified key concepts to serve as the conceptual framework for an elementary science curriculum. It is interesting to note that these concepts are limited in number; in only ten statements, presented in the section that follows, we have been able to encompass the principal achievements of all of science. These key concepts are the backbone of the science curriculum developed in this series. Each of the concepts has been broken down into elements and the elements arranged from the simple to the more complex, so that the structure of a discipline is gradually acquired by pupils as they progress through the grades. Examples of such sequential development follow.

1 *Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.*

Throughout his study of science in elementary school, the child ought to come to grips with the ques-

tion of what science is all about and how the scientist proceeds to carry out his work. To many children, science merely means such things as satellites going off into space, mysterious brews bubbling over Bunsen burners, or tiny forms of life being viewed under microscopes. The children identify conspicuous activities of some scientists as being science itself, erroneously viewing the purpose of the scientist as essentially practical—to make life easier, safer, and more livable for man.

How can we convey a different picture? How can we help the child to acquire a concept of science as a search for order in the universe? Even the young child is aware of events in the natural environment. He is aware of change—day changing into night, leaves falling and new leaves appearing, grass turning brown and then green again, weather changing, living things changing with age. But what the child is not aware of is that events happen in an orderly rather than in a haphazard, or chaotic, way. The child who first enters school is inclined to explain events by anthropomorphism, attributing to natural phenomena either a human knowledge or a human-like will to make things happen. Thus, grass turns green "because it wants to and because green is prettier," and birds fly south "because they know that winter is coming." The problem for the teacher is to encourage and help children to view science as an attempt to explain natural phenomena, not in terms of anthropomorphism, but in terms of certain fundamental natural laws.

There are several ways to accomplish this objective. The content of science itself helps. The primary school pupil studies tornadoes not as chaotic events but as the result of changes in air conditions. He finds out that a seesaw is balanced not because "the seesaw wants to," but because the *forces* on each side of the seesaw are balanced. Scientific explanations for familiar phenomena help the child appreciate science.

Emphasizing the key concepts that make up the structure of science is another way to help children to view science as a search for order in the universe. For example, the child who from the first grade has been exposed to basic concepts about the motion of objects tends to develop a conception of science as a search for basic laws. Such a conception is radically different from the conception of the child who continually interprets events in the world of nature in terms of their meaning for man only. A science curriculum that emphasizes such concepts as that some animals are useful to man conveys a very different idea of science from that conveyed by a curriculum that says that no two offspring of an animal are alike; differences passed on from generation to generation tend to accumulate, so that over millions of years a tremendous variety of living things has evolved on the earth ("Life on the Earth," Book 6).

Exposing a pupil to the "scientist's science" is one way of widening the child's appreciation of science. Another way is to include a historical perspective of science. In *Science for Tomorrow's World,* for example, as children find out how man's ideas of the solar system have changed over the centuries, the children come to view science as a questing for better answers. One "Pathfinders in Science" section in Book 3 illustrates how the genius of one man, Copernicus, caused an unwieldy concept of what is happening in the world of nature to be replaced by a more lawful concept—one that fitted the facts and explained the solar system more simply.

Still another way of conveying to pupils that science is a search for laws that explain events in the natural environment is to expose the children to the methods of science. Beginning with Book 3 of this series, and in each succeeding book, there is an introductory unit that conveys to pupils what the scientist tries to do and how he goes about his work. The child sees the importance of observation at every point. From observations of similar situations, he, like the scientist, tries to extract a kernel of knowledge, a principle that has wide application. The kernel is a

hypothesis only, for as the child comes to realize, a scientific principle is tentative; it may or may not explain new observations, and so ultimately it may have to be discarded for a point of view that can deal more successfully with the phenomena to be understood. Over and over again, the pupil finds out how man has changed his viewpoint on many things—the nature of changes on the surface of the earth (Book 3), the movement of the planets in the solar system (Books 3 and 6), what light really is (Books 4 and 6), what all matter consists of (Books 4, 5, and 6), and how magnetism and electricity are related (Book 6).

2 *Lawful change is characteristic of events in the natural environment; although living things tend to produce living things like themselves, over millions of years the earth and living things on the earth have changed, and diversified forms of life have evolved.*

As we have pointed out, even the young child is conscious of changes in the natural environment, but he lacks, as did man for thousands of years, the historical perspective. The young child does not realize the cumulative effect of the small changes that he sees going on about him. Waters may muddy as they tear away at the banks of a brook or a creek, but the child does not see that a Grand Canyon is ultimately produced by such forces. He hears of a new breed of insect that is immune to DDT, but he does not see the same principle at work producing the tremendous variety of living things in existence today.

In this series, throughout each of the books, the child is exposed to the concept of orderly change. This concept of orderly change over an extended period of time begins in Book 2 with the account of the life cycle of the moth. In Book 3, the pupil is introduced to the notion of changes in living things and in the surface of the earth, while in later grades these changes are spelled out in considerably more detail. For example, in the unit entitled "How Animals Behave" (Book 6), the reader finds out how two separate families, dogs and cats, evolved gradually from a common ancestor.

3 *To find order in the natural environment, the scientist seeks basic units that can be put together in an almost infinite variety of ways; the cell and the atom are examples of such units.*

We begin the development of this concept by helping the young pupil to discover the fact that, like all other substances, air takes up space. In fact, the door of an "empty" car may be hard to close because of the pressure of air inside the car. The child can find out more about the "stuff" of which air is made by warming the air in a closed glass container and watching the beads of water collect on the cover. From such experiences he discovers that matter can exist in particles that are too small to be seen with the naked eye—particles such as the individual molecules of water in a cloud of water vapor or the individual cells that make up the pupil's body. Beginning in grade 4, he can use a magnifying glass to make some very small things visible and to examine actual cells or pictures of cells with a microscope. His knowledge of the structure of the cell is expanded, bit by bit, and the bits are related more fully in a separate unit on cells in Book 5. Similarly, readiness for the study of the atom is built throughout the grades, culminating in the chemistry unit in Book 5.

4 *All objects in the universe and all particles of matter are constantly in motion; man has discovered and stated the laws governing their motion.*

The study of the basic science of motion begins in Book 1. Here the pupil learns that things do not start to move by themselves: A push or pull, called a *force*, is necessary to make a thing move. As the pupil advances to Book 6, page 106, he will learn the formal

name for the principle introduced here—the principle of inertia—but for the first grade, the concept is developed without use of a formal name. The second grade pupil learns more about the laws of motion: Once an object is moving, it continues to move in the same direction and at the same speed, unless another force acts upon it; for example, a passenger in a car continues to move forward when the car stops suddenly, unless a force in the opposite direction is applied by an opposing object, such as a seat belt. In Book 2, he also discovers that a steady force on an object in motion will make the object speed up. In Book 5, the pupil delves into the discoveries of Newton and learns that an object shot off into space has two kinds of force acting on it—a forward force, causing the object to continue in the same path and at the same speed at which it started (a review of the concept taught in Book 2), and a downward force, resulting from the force of gravity (a review of a concept taught in Book 3). The effect of these two kinds of force working on the object is that the object follows a curved path, since the constant forward force of the object is continually being deflected by the constant force of gravity.

The motions of heavenly bodies and the laws governing those motions are also presented in step-by-step fashion. The primary grade pupil finds out how movements of the earth in relation to the sun cause daily and seasonal changes, while the intermediate grade child studies the differing theories of Ptolemy and Copernicus to better understand the motions in the solar system. The movement of stars as a navigational aid is explained in Book 8, and the meaning and use of time zones is included in Book 9.

Not only are the motions of the largest objects in the universe covered by this key concept, but so also are the motions of the smallest particles. In grade 4, the pupil is first introduced to the concept of molecules and their motion in moving air. The grade 5 pupil learns that the state of matter—solid, liquid, or gas—is determined by the motion of molecules, and the grade 6 pupil finds out about the rotations of electrons within the atom.

The study of motion is not confined to the physical sciences. As the pupil studies the circulation of blood (Books 3 and 5), the transportation systems of plants (Books 4 and 6), and the movement of materials in and out of cells (Books 3, 4, 5, and 6), he has the opportunity to apply physical principles (such as the concept of diffusion) to the functioning of living organisms.

5 *The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.*

To the elementary school pupil, it may seem unreal that the particles of matter in all objects are constantly in motion. It may be hard for him to think of his desk, for example, as being made up of moving particles. In his desk, as in any solid, the average position of the particles is fixed; they cannot move past one another, although they can vibrate. But if the pupil rubs his fist hard and fast over the surface of the desk, the spot warms up as the particles move more rapidly and farther apart. He can infer from certain experiences—the transfer of heat from warm things to cold things, the expansion of hot objects and the contraction of cold objects, the heating up of a wire carrying an electric current, the growing of a crystal in solution, the process of chemical change—that particles *do* exist and that they must be in motion to produce the phenomena he is observing. In fact, it is *only* as the pupil becomes aware of the motion of molecules that he can understand such phenomena as heat, light, electricity, magnetism, and chemical change.

Readiness for the concept of molecular activity begins in the primary grades. In Book 1, the child discovers that there is a relationship between temperature and rate of evaporation. In Book 2, the effect of heat upon volume of gases and liquids is introduced,

as is the relationship of heat to changes in state of matter from solid to liquid to gas. In Book 4, the pupil finds out about electron motion in current electricity, and in Books 5 and 6, he learns about the structure of the atom and the concept of the motion of particles applied explicitly to heat, light, electricity, magnetism, and chemical change.

6 *There is a basic tendency toward stability or equilibrium in the universe; thus, energy and matter may be transformed, but the sum total of matter and energy is conserved.*

Beginning with Book 2, pupils get their first exposure to one of the key concepts of science—conservation of matter. At this level, pupils discover that the matter (a ball of cookie dough) remains the same even though the matter may be transformed in appearance (made into cookies). In grade 3, in connection with a study of changes on the earth, pupils find out that while a river may cut deeper and deeper into its bed, carrying away soil in the process, the soil that is carried away does not dissolve into nothingness in the water. The soil may be transported and dropped at the river's mouth, but it is not lost. *The total amount of matter in the system at any point in the transformation remains the same.*

Similarly, the pupil learns that energy can be transformed. The primary child can understand that energy in the form of gasoline in the tank of a car must be transformed by burning if the car is to be able to move. In the same way, energy is produced in the body when food is burned during the digestive process. Furthermore, there is a relationship between the amount of energy available to do work and the intake of fuel or food. A car without gas will stop, and a hungry person soon becomes tired. Such commonplace, easily understood examples provide the basis for understanding the concept that although man may make transformations in a system, the equation for the system will balance at the end of the transformation.

7 *When equilibrium is upset in organism-environment interactions, regulatory mechanisms go to work to restore equilibrium.*

This key concept involves the basic tendency of organisms to strive for equilibrium. Temperature regulation is one of the best-known examples. In human beings, equilibrium with respect to body temperature exists at about 98.6° F. Evaporation of water from any surface has a cooling effect. When the body becomes overheated, we perspire, and equilibrium is restored; when the body is chilled, goose bumps on the skin reduce the exposure of blood vessels to the cold, and body heat is conserved. When equilibrium in body temperature is restored, the goose bumps subside.

From the simplest plants and animals to the most complex, we can find illustrations of how certain mechanisms go to work to restore equilibrium when it has been upset. These mechanisms serve the function of helping the organism to survive.

8 *There is a relationship between structure and function; the structure of parts of living organisms determines the function of those parts.*

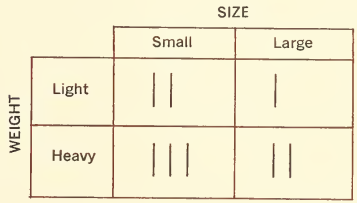
In the development of this key concept, we use the same approach as for the other key concepts in *Science for Tomorrow's World*. We begin in the primary grades with examples of the relationship between structure and function. Even the first grade pupil can observe in real life or in pictures that not all birds can scoop up fish from the sea or dig for insects in the trunk of a tree. Observations lead to the concept that the beak structure of a bird enables the bird to obtain food in a special way—a concept that leads to further observation and discovery of more specifics. For the older pupil, the relationship is stated explicitly. First

the pupil is exposed to many examples: in the unit on "How Animals Behave" (Book 6), there is a detailed discussion of the sensory receptors of animals—from the planarian to the fish. The remarkable chemical receptors of the male fish not only enable it to detect male-female differences in other fish of the same species, but also to detect when the female is ready to mate. Even the simple planarian, as pupils can observe, uses chemical receptors on each side of its head to detect food, waving the receptors from side to side to find the greatest source of stimulation. Thus, the key concept is stated for the pupils: "The way in which sensory receptors are made (their structure) is related to how they work." The pupils are then asked to apply the concept to any independent observations they make of animals not discussed in the text.

9 *The scientist has developed measures of space, time, and matter so that he can communicate explanations that are reproducible and make predictions about events in the natural environment.*

That there is a relationship between mathematics and science is common knowledge. The student, however, should be encouraged to deal with the relationship well before he has to use calculus in high school physics; as is true for other key concepts in the basic structure of science, readiness should begin in the primary grades.

The first step in a pupil's appreciation of the relationship between mathematics and science is to have him quantify his data. This can begin in the first grade. A pupil learns that a seesaw is in equilibrium when the same number of books of equal size and weight are placed equidistant on both sides of the fulcrum. Through experience, he learns to coordinate weight and distance in a systematic way; a large weight at a small distance on one side balances a small weight at a large distance on the other side. Quantification of data extends to record keeping, and *record keeping involving two variables is encouraged.* In Book 2, for example, pupils learn to keep a record of the temperatures of jars of water that have been covered with materials of different colors. The children also learn to record the length of time that the jars are kept in the sun. Thus, both temperature *and* time are recorded. The important mathematical concept of *function*—that a change in one variable can result from a change in another—receives reinforcement here. Record keeping in the form of a double-entry table is encouraged. Use of such tables need not be postponed until the upper grades; even a pupil in the second grade can learn to read a double-entry table, as well as to classify certain objects in terms of size and weight:




This chart, for example, shows that of the objects to be classified, two are small and light, one is large and light, three are small and heavy, and two are large and heavy.

Many experiences of this kind help the pupil to develop the mental agility needed to deal with concepts involving two variables. Thus, in *Science for Tomorrow's World, speed* is defined in terms of distance covered in a certain length of time; *density* is defined by the amount of matter contained in a given volume of space; *force* is defined by the relationship between mass and acceleration. The pupil who can see such concepts on a graph is clearly better equipped to deal with these concepts. He can think more understand-

ingly about them because his mind has been trained to think in this fashion during the period of his elementary school years.

Two units in particular in *Science for Tomorrow's World* are devoted to the relationship between mathematics and science. Book 5 contains a unit on "Testing Ideas," which introduces pupils to probability theory; an entire unit in Book 6 is devoted to developing the concepts of "a unit of measurement" and the "meaning and methods of measuring space, time, and matter."

10 *Man has changed and continues to change the natural environment; but because he is often ignorant of long-range consequences, his actions may have harmful effects for himself and for other living organisms.*

One of the basic problems facing modern man is that of maintaining a dynamic equilibrium with his environment. It is commonplace today to point out the rapid pace at which man is depleting elements of his environment. Water and air pollution, overpopulation, and improper use of chemicals are only a few of the many problems that man must solve if he is to function at an optimum level in the world of nature. Many such problems arise because man does not foresee the long-range consequences of his actions. For example, no one was able to predict that the wholesale use of DDT for the spraying of insects would result in the killing of many birds, or that the clam and oyster industries along parts of the Atlantic seaboard would be threatened by the dumping of wastes into coastal waters. Man must begin to develop foresight if he is to survive; he must become more concerned with the *total* natural environment.

There are moral and philosophical, as well as scientific, considerations involved in the above key concept about man and the natural environment, and obviously the elementary school child is not equipped to deal with them. But even a second grade pupil is capable of understanding that living things need air, water, food, and proper temperatures to survive. He can find out by experimentation what happens to plants deprived of one or more of these essentials of life. Third grade children can learn what is needed to make safe drinking water and, also, how man has contributed to water pollution. By the fifth and sixth grades, pupils are ready for a study in greater depth of some of the many other problems of man's own making ("Life on the Earth," Book 6). Of course, pupils cannot arrive at solutions to these problems, but the teacher can create a climate of opinion so that in later years, as adults, these same pupils will be more aware of both the necessity of managing natural resources with greater intelligence and the long and thorough pilot studies that are needed before any new products and solutions can receive full-scale application.

The ten key concepts that we have discussed form the structure of science in *The Macmillan Science Series*. Two things are worth emphasizing about these key concepts. The first is that all of the structure of science can be set forth in *so short a list;* the second is that there is considerable agreement among scientists that these ten key concepts actually *do structure science*. The reader may be interested in comparing the key concepts basic to *The Macmillan Science Series* with the set of propositions published by the National Science Teachers Association. These propositions are the result of extensive studies concerning the question of what to teach elementary school children. These studies were carried out by scientists and teachers working together. The following list, quoted from *Theory into Action,* published by the National Science Teachers Association, Washington, D.C., (1964) represents seven conceptual schemes and five major items in the process of science that were tentatively defined by the NSTA Committee as constituting the structure of science.

1. *All matter is composed of units called fundamental particles; under certain conditions, these particles can be transformed into energy, and vice versa.*

2. *Matter exists in the form of units which can be classified into hierarchies of organizational levels.*

3. *The behavior of matter in the universe can be described on a statistical basis.*

4. *Units of matter interact. All ordinary interactions are either electromagnetic, gravitational, or nuclear forces.*

5. *All interacting units of matter tend toward equilibrium states in which the energy content . . . is at a minimum and the energy distribution . . . is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.*

6. *One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, and gas.*

7. *All matter exists in time and space, and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.*

The following are the five major items identified as essential to the process of science:

1. *Science proceeds on the assumption, based on centuries of experience, that the universe is not capricious.*

2. *Scientific knowledge is based on observations of samples of matter that are accessible to public investigation in contrast to purely private inspection.*

3. *Science proceeds in piecemeal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.*

4. *Science is not, and will probably never be, a finished enterprise, and there remains very much more to be discovered about how things in the universe behave and how they are interrelated.*

5. *Measurement is an important feature of most branches of modern science because the formulation as well as the establishment of laws is facilitated through the development of quantitative distinctions.*

## SEQUENCE IN THE SCIENCE CURRICULUM

The task of curriculum building in science includes a number of steps, the first of which is the identification of the key concepts that together add up to an understanding of the meaning of science. These key concepts have already been discussed. We have included in *Science for Tomorrow's World*, at the various grade levels, illustrations of these key concepts so that the children may see them materialized in learning situations. However, it is also essential that each key concept systematically be broken down into smaller pieces of relevant information. These smaller pieces must be arranged in sequential order from simple to the more complex, and the pieces must be assigned to proper grade levels.

A well-constructed development of concepts, taught in "spiral fashion" throughout the elementary school years (reinforcing every other year or two what has been learned earlier, and then advancing to a higher level of understanding) is essential for a meaningful understanding of science. The charts on the next two pages illustrate the sequence that has been developed in *Science for Tomorrow's World*.

1 Events in the natural environment happen in an orderly rather than a haphazard way; man searches for laws to explain this order by observing, hypothesizing, checking his ideas, and rejecting those which do not square with reality.

2 Lawful change is characteristic of events in the natural environment; although living things tend to produce living things like themselves, over millions of years the earth and living things on the earth have changed, and diversified forms of life have evolved.

3 To find order in the natural environment, the scientist seeks basic units that can be put together in an almost infinite variety of ways; the cell and the atom are examples of such units.

4 All objects in the universe and all particles of matter are constantly in motion; man has discovered and stated the laws governing their motion.

5 The motion of particles helps to explain such phenomena as heat, light, electricity, magnetism, and chemical change.

## BOOKS IN WHICH KEY CONCEPTS ARE DEVELOPED AND THE NUMBER OF UNITS IN EACH BOOK DEALING WITH THE CONCEPT

| *KEY CONCEPTS* | *BOOKS* | | | | | | *TOTAL UNITS* |
|---|---|---|---|---|---|---|---|
| | 1 (6)* | 2 (6) | 3 (6) | 4 (9) | 5 (9) | 6 (9) | |
| 1 | 6 | 6 | 6 | 9 | 9 | 9 | 45 |
| 2 | 1 | 3 | 1 | 1 | 1 | 2 | 9 |
| 3 | 0 | 1 | 1 | 2 | 3 | 5 | 12 |
| 4 | 1 | 3 | 1 | 1 | 3 | 3 | 12 |
| 5 | 3 | 3 | 0 | 1 | 2 | 3 | 12 |
| 6 | 2 | 3 | 1 | 5 | 4 | 3 | 18 |
| 7 | 1 | 3 | 1 | 1 | 2 | 2 | 10 |
| 8 | 3 | 2 | 1 | 2 | 3 | 2 | 13 |
| 9 | 1 | 2 | 0 | 2 | 4 | 7 | 16 |
| 10 | 0 | 0 | 1 | 0 | 1 | 1 | 3 |
| *Total Concepts* | 8 | 9 | 8 | 9 | 10 | 10 | |

** Number of units in the book*

**6** There is a basic tendency toward stability or equilibrium in the universe; thus, energy and matter may be transformed, but the sum total of matter and energy is conserved.

**7** When equilibrium is upset in organism-environment interactions, regulatory mechanisms go to work to restore equilibrium.

**8** There is a relationship between structure and function; the structure of parts of living organisms determines the function of those parts.

**9** The scientist has developed measures of space, time, and matter so that he can communicate explanations that are reproducible and make predictions about events in the natural environment.

**10** Man has changed and continues to change the natural environment; but because he is often ignorant of long-range consequences, his actions may have harmful effects for himself and for other living organisms.

## UNITS IN WHICH KEY CONCEPTS ARE INTRODUCED IN BOOK 1

| *KEY CONCEPTS* | *UNITS* | | | | | | *TOTAL UNITS* |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | X | X | X | X | X | X | 6 |
| 2 | | | | | | X | 1 |
| 3 | | | | | | | 0 |
| 4 | | | X | | | | 1 |
| 5 | X | | X | | X | | 3 |
| 6 | X | X | | | | | 2 |
| 7 | | X | | | | | 1 |
| 8 | | | | X | X | X | 3 |
| 9 | X | | | | | | 1 |
| 10 | | | | | | | 0 |
| *Total Concepts* | 4 | 3 | 3 | 2 | 3 | 3 | |

## TEACHING UNITS

Once major generalizations have been identified and the flow of ideas from grade to grade is roughed out, it then becomes necessary to plan teaching units suitable to the developmental level of the child. Each unit covers a period of instruction varying in length from two to four weeks. Such an arrangement of text material in eight or nine major blocks of subject matter permits more efficient teaching and learning than when a text is divided into thirty chapters with a different topic for each chapter. Under the unit arrangement the teacher does not shift gears every few days, having to gather equipment with each shift as well as having to reorient pupils' thinking.

The Table of Contents, which lists the titles of each unit of the first six books, is reproduced in Part IV. By looking at the titles, a teacher can tell at a glance whether or not the pupils have had any previous exposure to a particular area. The sequence charts on page 20 will reveal the amount and quality of the exposure.

An examination of the titles reveals some immediately familiar areas in science education. Such topics as "Probing the Atmosphere," "Living Things—Green Plants," "Light and Sight," and "Using Electricity" have been part of the elementary science curriculum for many years; although, as has already been pointed out, the specifics taught under each topic have often been different. In studying about light, for example, the children do not learn only that light is made up of particles traveling in a straight line; the children also learn that light particles travel in a wave motion, similar to the motion of a water wave when a pebble is dropped into a pond. Elements of key concepts are built into the topics, so that, although the topic itself is not new to the curriculum, each element becomes a vehicle for teaching the structure of science from a contemporary point of view.

Some topics reveal new developments in the sciences. Conservation of water resources and problems of air pollution are being emphasized today as much as conservation of soil was emphasized a few decades ago. This trend is reflected in the unit "Life on the Earth" (Book 6). Oceanography, for another example, is a rapidly expanding field of knowledge. With so many basic scientific data now known about life in the sea, ocean currents, salinity, and the geology of the ocean floor, the study of oceanography well deserves a place in the elementary science curriculum. The picture story "Probing the Oceans" (Book 5) highlights the work of oceanographers at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, and will stimulate interest in this exciting field. Similarly, the stepped-up pace of man's exploration of space leads not only to the inclusion of space travel, but also to an increased emphasis on the science of astronomy.

# PART II: HOW CHILDREN ACQUIRE SCIENCE KNOWLEDGE: A DEVELOPMENTAL APPROACH

For any discussion of how children acquire science knowledge, educators today lean heavily on the work of Jean Piaget, a Swiss psychologist who has been working with his collaborators in Geneva for over 40 years on the study of cognitive processes. Cognitive processes are those intellective processes by which knowledge is acquired. Piaget has developed a theory of how these processes begin in infancy and how they change as the child matures. His theory is a developmental one; characteristics of children's thinking are described in age-related stages. On the basis of Piaget's theory, we can predict the thought processes of children within a certain age range. There are, of course, individual differences in maturity of thinking; some children, because of heredity and experience, are more advanced than others; but, according to Piaget, the thinking of all children tends to go through the same stages and, on the average, when they are at the same age.

Piaget's description of developmental stages in children's thinking has generated a tremendous amount of research on both sides of the Atlantic. Many investigators have worked on the problem of whether or not his theory is a valid one. The conclusion to date is affirmative; the same stages characterize the thinking of Swiss, Norwegian, English, French, Canadian, and American children. In fact, when the tests developed by Piaget and his chief collaborator, Barbel Inhelder, are given to subjects in different countries, investigators report that translations show almost identical wording in children's answers. American cognitive psychologists, like Jerome Bruner of Harvard University, have extended and refined Piaget's theory, so that today we have a well-constructed and validated model of the thinking processes involved in the acquisition of knowledge. An understanding of how children acquire knowledge is basic to improvement of the teaching-learning process; we cannot help children to become better thinkers unless we know something about thinking processes and how they change with age, nor can we construct effective textbooks without taking into account developmental changes in cognition.

How can we put the findings of Piaget and other cognitive psychologists to work in teaching science? As we have pointed out, one of the aims of science educators is to teach the methods of science, to teach the child to use the same logical processes of thinking that a scientist uses to solve problems. For too long,

teaching the methods of science has meant teaching children to follow a formula: Observe; Hypothesize; Test; Evaluate. The formula is still valid, but it is not enough. The child in primary grades *does* observe, but, as we know from Piaget's work, he is likely to focus on the wrong property of an object or event as he observes. Similarly, the pupil in intermediate grades *does* hypothesize, but if he picks out the wrong variable for testing, he doesn't know what to do next. Nor does he know what to do next if he gets positive results from testing, for he doesn't know the specifics of "Evaluate"; he doesn't know, for example, that he must test for ex*clusion* of other variables.

In developing *Science for Tomorrow's World* we set as goals that the texts should not only help the child build a structure of science (the scientist's science), but should also develop logical thought processes. We believe that the study of science can help children become better thinkers, but that there must be deliberate planning to achieve this end; the improvement of thinking processes should not be left to chance. Guided by the discoveries of Piaget and other cognitive psychologists, we have used content, activities, and illustrations in the series to foster logical thinking. We will now discuss what is known about the normal course of intellective development, before discussing how that knowledge can be put to use in teaching science.

For Piaget the development of intelligence begins as early as the cradle stage and continues through stages from birth to maturity. The first stage Piaget calls the sensorimotor. The infant comes into the world with two kinds of reflexes: those, such as the knee-jerk, that are not altered by experience, and others, such as grasping and sucking, that are modified as the infant exercises them. The modification occurs through assimilation and accommodation. The infant, for example, accommodates the grasping reflex to the shape of the object to be grasped, curving his fingers one way to grasp a long narrow object, and in a different way to grasp a ring. During the first 18 months, the infant carries on countless transactions involving space, time, matter, and causality which build and reshape developing mental structures. Witness what happens with respect to the notion of permanence of object. To the 2-month-old infant, the game of peek-a-boo is meaningless; for him an object ceases to exist when it disappears from view, and out-of-sight is out-of-mind. Later in the first year of life, the infant knows that an object continues to exist and delights in searching for it when it is hidden. He "knows," not in words, but in his sensorimotor system, in much the same way that we may "know" how to find our way through a still strange building the second time. For Piaget, sensorimotor intelligence is the intelligence of action. The infant must first carry out displacements in his *actions,* rather than in thought. If an object is hidden first in one place and then another while the toddler looks on, he must carry on a physical search for that object, going from cushion to cushion; he cannot sit back and point triumphantly to where the object is, for he cannot visualize its displacement in his mind. However, by 18 months the child is capable of representation, of imagining the environment other than as he directly perceives it.

The next stage, the *preoperational,* extends from 18 months, roughly, to about 7 years. It is in this stage that we find most first and second grade children—and, of course, some children even older than 7 years. This stage is called "preoperational" because the child does not use logical operations in his thinking. We can summarize the characteristics of pupils' thinking at this level as follows:

1. *The child is perceptually oriented; he makes judgments in terms of how things look to him.* When given a problem in which two lines of ten segmented sticks of equal length are laid out in parallel rows, he will see that both lines are equal. He will see that two dolls, walking along these paths, would each walk the

same total distance. But if one of the rows is rearranged in a zig-zag fashion, when the child is again asked if each doll takes as long a walk as the other, the child says, "No." Even when he counts the segments, he denies equality; the child does not see that there is a logical necessity in which ten must equal ten. Piaget has shown that this same type of perceptual judgment enters into the preoperational child's thinking about space, time, number, and causality. It is only as the child goes beyond his perceptions to perform displacements upon the data in his mind (for example, visualizing the second row of sticks straightened out again) that conservation appears.

2. *The child centers on one variable only, usually the variable that stands out visually; he lacks the ability to coordinate variables.* For example, a kindergarten child is pouring juice into paper cups. The standard-size cups run out, and the teacher substitutes some that are much higher but are also smaller in diameter. As the children drink their juice, several comment on the fact that Jimmy, Eddie, and Danny have more juice. Why? Because those children have cups that are taller. The dimension of height, not width, stands out. The child's thinking is rigid; he does not perform operations on what he sees. Later he will reason that "higher than" is compensated for by "skinnier than," and that both kinds of cups may hold the same amount of juice. This ability to see reciprocal changes in two sets of data is an important logical tool available to older children but not to the preoperational child.

3. *The child has difficulty in realizing that an object can possess more than one property, and that multiple classifications are possible.* It is hard for the child to see that one can live in Los Angeles and in California at the same time, that a bird is also an animal, and that, since there are animals other than birds, there are logically more animals in the world than there are birds. The operation of combining elements to form a whole and then seeing a part in relation to the whole has not as yet developed, and so hierarchical relationships cannot be mastered.

So far, this consideration of preoperational thinking has been largely negative. We have seen that the child lacks the ability to combine parts into a whole, to put parts together in different ways, and to reverse processes. What, then, can the child do? The development of logical processes is not at a standstill during this period; there are some positive accomplishments. We see, for example, the rudiments of classification: the child can make collections of things on the basis of some criterion; he can also shift that criterion. Thus if we present a kindergarten child with a collection of pink and blue squares and circles, some large and some small, and ask him to sort them into two piles with those in each pile being alike in some way, he can usually make two different collections on the bases of color and shape (a few children discover the third criterion of size). Such an ability, of course, is essential to the formation of classes and eventually of a hierarchy of classes.

The child is also beginning to arrange things in a series. He can compare two members of a set when they are in a consecutive order; he knows that Tuesday comes after Monday. But since Friday comes after Tuesday, which is after Monday, does Friday also come after Monday? This operation, involving seeing logical relations between things or events that are arranged in a series, is not yet possible to the preoperational child, but experiences with seriation are preparatory to the development of such operations. The "inching up" that an older pupil does in trying to establish equilibrium between two parts of a physical system (add a little to one side; then add a little to the other) is an example of a more sophisticated use of seriation.

Between 7 and 11 years of age on the average,

as the child assimilates information from his actions and accommodates mental structures to the new information, thinking processes change. The child abandons his perceptual judgments and thought takes on certain logical properties. Piaget calls this stage the stage of *concrete operations,* because, while the child uses logical operations, the content of his thinking is concrete rather than abstract. One of the mental operations that develops is that of combining elements; the child begins to put two and two together figuratively as well as literally. He uses this combining operation to discover (though not until toward the end of this stage) that a substance like sugar added to water will make the water level rise, and that the water level will stay up even after the sugar dissolves. It dawns on the pupil that matter combined with matter produces more matter, that matter doesn't disappear into nothingness.

Another property of logical thought is that elements of a whole can be associated in various ways without changing the total. Thus, in the problem of the segmented sticks, the segments can be "associated" in a straight line or zig-zag line, but the total distance of the path to be covered remains the same, or is conserved. And in studying science, the pupil can use the associative operation to discover how to keep a system in equilibrium—how, for example, when a muscle is flexed, it becomes shorter but thicker; when relaxed, it is longer but thinner. In each case, the total amount of muscle remains the same; the amount of matter is conserved, though its shape is changed.

A third property of logical thought is that of identity. The identity operation is basically a null operation; the child can mentally cancel out the effects of any operation by combining it with its opposite. He uses such an identity operation to reason that the effects of adding a force to one side of a balanced tug-of-war can be canceled out by adding a force to the other side (at the preoperational stage, he could solve the problem only by taking away the extra force that had been added). The pupil can also reason, as he thinks about a flexed muscle, that, since nothing has been added to the muscle and nothing has been taken away, then quantity of matter is identical before and after the flexing. An extension of the identity operation is the one-to-one correspondence a pupil carries on to establish identity between two sets. Is the spider an insect? The pupil must compare each characteristic in the set of insect characteristics with each in the spider set, on a one-to-one basis, to answer the question.

Of all of the properties of logical thinking, one of the most critical to develop is that of reversibility. Every change that the mind makes upon sensory data is reversible. The child can mentally rearrange the sticks in the zig-zag line, putting them back the way they were, to see that length is conserved. Similarly, a pupil can solve the problem of whether matter in a total system is conserved when a river carries away soil and deposits it in the river delta by reversing the depositing process. (See Book 3, Unit 3.)

A good deal of the research of Piaget and Inhelder on how children think about problems has centered on conservation problems in which matter, weight, or volume is conserved with a change in form. Results show that children achieve conservation during the stage of concrete operations, but that some conservation problems are easier than others. Conservation of length (the segmented sticks) appears first, followed in turn by conservation of matter (pouring sand into containers of different shapes) and conservation of weight. Conservation of volume (dissolution of sugar in water) is most difficult, appearing at about 11 years.

The operations described above characterize the thought processes of the child during the elementary school years, but beginning at about 12 years, there are further changes that occur in modes of thinking. Thinking is less tied to the concrete and becomes more abstract and formal. Piaget describes it as *proposi-*

*tional* thinking. The pupil can state propositions in terms of the variables he has identified and can then systematically combine the propositions so as to test all possible combinations. To reveal thinking processes, a pupil is presented in one of Piaget's tests with four flasks containing colorless, odorless liquids that look exactly the same, plus a bottle containing potassium iodide (not identified for him). He is shown that a few drops from the bottle can turn the proper (but unknown to him) mixture of liquids yellow, and he is asked to reproduce the process. If the pupil is at the formal stage of thought, his statements will reveal certain characteristics of thinking not found in younger children. For example, he will say, "If this stuff in the bottle is plain water, then when I put it with a mixture from the first and second flasks, it shouldn't make them turn yellow." In effect he is stating a hypothesis for testing, "If it's water, it wouldn't do this," or that one statement logically implies another. At the concrete stage, the pupil says, "I'll put this and this together and see what happens."

There are four ways in which propositions can be combined. We can combine by conjunction, as when we say, "It's got to be this *and* this"; by disjunction: "It's got to be this or this"; by negation: "It's neither this nor this"; and by implication: "If it's this, then this will be true." Let's suppose, for example, that a sixth grade child is interested in the problem of what attracts certain insects to flowers; two possibilities are design and color. How to combine the two? At the formal stage of thinking, the learner can systematically test all the possibilities by asking:

Is it color and not design?

If it's not color, then is it design?

Is it design and color?

Is it neither?

Each of these questions must next be stated as a hypothesis for testing. The question, "Is it color and not design?" must be restated as the hypothesis, "If it's color and not design, then when we present both stimuli (which are specified) to the insect, we ought to attract more insects to the color." But following the checking out of that hypothesis, if color "works," the pupil must then ask, "If it's color, is it any color? Does yellow work as well as red? Do fluorescent colors work better than nonfluorescent? If color red is equal to color yellow, the number of insects attracted to the stimuli should be the same." The outstanding characteristic of thought at the formal stage is the way in which the mind can combine propositions, going back and forth with lightning-like speed, and then stating what the combination implies in the way of experimental outcome. This mode of thinking begins to appear in bright children even before they leave elementary school.

## BUILDING A SCIENCE SERIES TO FOSTER LOGICAL THINKING

The developmental picture we have described has implications for building a science series to foster logical thinking, as we shall see. However, it should be pointed out here that cognitive psychologists have made contributions other than the developmental picture. Piaget and Inhelder have given us insight into the misconceptions about science that children acquire, so that we can plan remedial activities. Bruner has described the process of concept building, a process that begins with a sensorimotor experience, proceeds to a step where a mental image is important, and then is completed at the symbolic level, where verbal understanding is accomplished. Aspects of cognitive theory other than the developmental picture have been considered in building our science series.

### Implications of Cognitive Theory for Content Selection and Grade Placement

In building a science series, there must be a rationale for the selection and grade placement of sub-

ject matter. Part of the rationale is derived from scientists' analysis of what is important in science; we have selected for the content in this series the "scientist's science," ordered in terms of difficulty of concepts. Part of the rationale is derived, also, from what we know about the child. If the study of science is to improve thinking processes as the pupil acquires content, strategy for improvement must be based on what is known of the normal course of intellective development. In our discussion thus far, we have described the *normal course,* not the potential; it is with the norm that we start to accelerate development, for American educators are rarely interested in maintaining the status quo in achievement levels. Knowing the characteristics of preoperational thought, we selected content for the primary books in this series that will help the child overcome preoperational deficiencies and facilitate development of those properties of logical thought that appear in the stage of concrete operations. Knowing how the child thinks at the stage of concrete operations, we selected content for the middle grades to strengthen logical operations and advance the onset of propositional thinking. As previously stated, we take the position in this series that the development of the highest mental processes should not be left to chance; the school should foster logical thinking in every way possible, and the study of science offers unique opportunities to do this.

Some examples at this point may help to clarify our strategy. Particularly in the first two books, we present learning situations to help the child overcome his tendency to make perceptual judgments and to center on one variable. In Book 1, for example, the pupil is helped to discover that *both* weight at each end *and* distance from the fulcrum must be considered in balancing the seesaw; centering on the weight variable is not enough. In Book 2, the young reader has experiences in co*ordinating* two variables; as he pours sand into containers of different shapes, he learns that "higher than" is compensated for by "skinnier than," so that quantity of matter is conserved. He is also given practice in identifying more than one property in classification problems; he discovers that sounds vary in *both* volume and pitch, and he works out with the teacher a 2 x 2 table (see page 4) to visualize the classification of the sounds to which he is listening.

But what of pupils in the first two grades whose thinking has advanced beyond the preoperational level? For such pupils, logical operations should be made explicit by the teacher so that their use, which may be only intuitive at first, will be strengthened. And the teacher, knowing the logical operations that appear in the average child 7 years old, can make every effort in all of her teaching to strengthen such thinking processes as they appear in pupils in the first two grades.

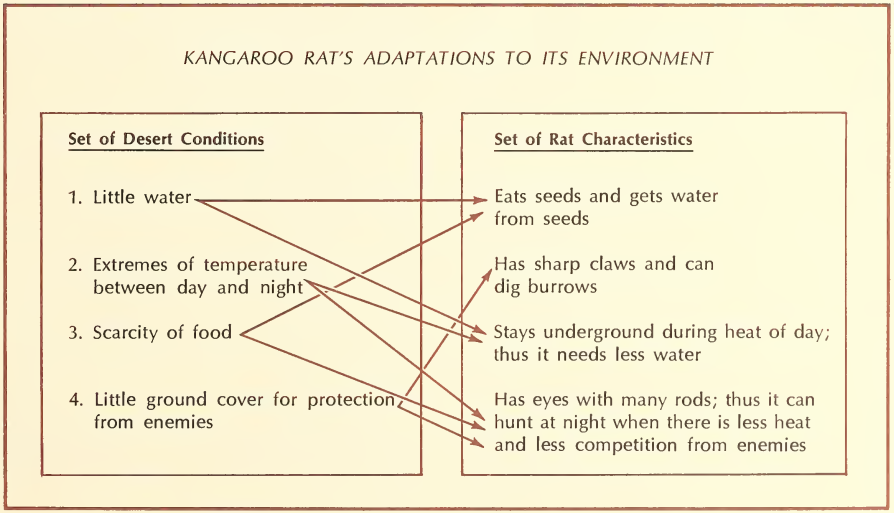
In Books 3, 4, and 5 there is increased emphasis on developing in the pupil these logical operations—combining elements, associating elements in different ways, establishing identity between elements, and reversing an operation—that characterize the stage of concrete operations (normally 7–11 years). There is considerable work, particularly in Books 3 and 4, on classification skills. Such skills began in Book 2, when a pupil learned to describe a specimen by more than one characteristic and then, to identify the specimen as either a butterfly or moth, to make a one-to-one correspondence between the characteristics of the specimen and those of the butterfly or moth. In Book 4, Unit 4, skills become more complex as the pupil learns about hierarchical classification. Fishes, amphibians, reptiles, birds, and mammals can be combined to form a superclass of "animals with backbones." Furthermore, certain things are logically true of the superclass and the subclasses (e.g., each member of the subclass must contain those characteristics that distinguish the superclass plus some others; a subclass is always smaller in number than the superclass.

Logical thinking is also demanded of the child in questions in the text or in the teaching suggestions.

Note the logical processes involved as a third grader attempts to answer the teacher's, "Can you give me an example of an animal that lives on the desert and explain how the animal can live in such an environment?" The pupil has read the unit "How Animals Live," Book 3, Unit 4, from which he learned about many animals adapted to many different environments. To answer the question, he must first combine elements that make up a set of desert conditions: little water, extremes of temperature, scarcity of food, little ground cover. He remembers the kangaroo rat as living on the desert, and combines elements that make up a set of rat characteristics: eats seeds and gets water from seeds, has sharp claws and can dig burrows, stays underground during heat of day and so needs less water, has eyes with many rods and so can hunt in the cool of the night. Then the pupil must set up a correspondence between elements in the desert-conditions set and elements in the rat set. If for the elements in the first set there are corresponding members in the other set, establishing an identity, then he knows the animal is adapted to desert living.

Logical operations continue to be emphasized in Grades 5 and 6, but in increasingly more complex situations. We can find many examples of operations particularly in the physical science content in Books 5 and 6. The development of the speed-time-distance relationship in Book 6 is a case in point. Note that the pupil must now see one variable as a function of two others and work out relationships among the three by using not one but several logical operations (reversibility, for example: if $s \times t = d$, then $s = d/t$; identity, as he puts in the correct numbers for the letter symbols).

Beginning in Book 5 and increasingly in Book 6, content encourages the pupil to do propositional


KANGAROO RAT'S ADAPTATIONS TO ITS ENVIRONMENT
Set of Desert Conditions
1. Little water
2. Extremes of temperature between day and night
3. Scarcity of food
4. Little ground cover for protection from enemies
Set of Rat Characteristics
Eats seeds and gets water from seeds
Has sharp claws and can dig burrows
Stays underground during heat of day; thus it needs less water
Has eyes with many rods; thus it can hunt at night when there is less heat and less competition from enemies

thinking. For example, in the introductory unit to Book 5, the reader is introduced to the specifics of scientific methods. He has, of course, been raising questions and doing "experiments" in the first three grades; he has even had practice in controlling certain factors while he experimented with another. In Book 2, for example, in the unit on heat, pupils experiment on the insulating qualities of different kinds of cloth. The size of the cloth and the temperature of the water to be protected are kept constant. But the question, "Does the color of clothes make a difference (in keeping us cool)?" is not stated as a hypothesis for testing. It implies a concrete operation, but it does not spell out the specifics for testing. It does, however, provide readiness for the fifth grader's encountering, in Unit 8, Book 5, the experiment, "How Do Dark and Light Colors Affect the Absorption of Heat Energy?"

There is one last point to consider in using the content of *Science for Tomorrow's World* to improve thinking processes. As Piaget has shown, the child deals less with the concrete and more with the abstract and the formal as thinking processes mature. We recognize this developmental change and have taken it into account in our planning to facilitate the appearance of abstract thinking, but we do not emphasize the formal expression of generalizations prematurely. There are many opportunities in the primary grades for pupils to deal with functions in a concrete way. In Book 2, for example, page 138, the pupil carries out an activity in which he discovers that the loss of heat over time is a function of the insulating properties of the protective material. This discovery as stated, however, is beyond the comprehension of most second grade children. Instead, the child of 7 summarizes in a concrete fashion: "With a wrapping made of wool, water doesn't cool off as fast as with wrappings made of cotton or rayon." In keeping with developmental theory, we reserve the more formal and abstract expressions of generalizations for Book 5 and Book 6.

## Implications of Cognitive Theory for Activities and Illustrations

Cognitive theory is useful not only in planning content and grade placement, but also in planning learning activities and experiments and in designing special illustrations for tests. The reader will recall that in Piaget's theory, the first stage is the sensorimotor, where the infant may be said to "think with his muscles." While language changes the mode of thinking, the need for a motor component as an underpinning for certain concepts does not disappear with the advent of speech. Bruner in particular has noted the importance of motor activity as a first step in concept building. In this series we have recognized the importance of sensorimotor experience in planning learning activities. No verbal description of how gears work can substitute for the actual manipulation of gears (See Book 2, p. 52). No verbal description can convince the child that the image formed in the retina of what he is seeing is an upside-down image, but let him try building a pinhole camera (Book 6, Unit 6), and he has built into his sensorimotor system a basic understanding of the concept.

Activities with a motor component are not new to science, but what is new is that we now have a rationale for which concepts need this kind of sensorimotor underpinning. Concepts from the physical sciences, where two different displacements occur at the same time, need a motor component. The activities in Books 2, 3, and 6 in the units dealing with concepts of forces and motion contain many examples of such displacements. Sensorimotor activities are often needed, also, to correct misconceptions children have built up. Cognitive theorists have provided us with information about which concepts children are likely to be confused about. In the process of living and adjusting to his environment, the child has been dealing with such phenomena as time, matter, space, light, heat, motion, and electricity, and has more likely than

not built up misconceptions around them. Most children, for example, think that a steady push on an object results in a steady speed. The sensorimotor experience of feeling acceleration in the wagon one pushes with a steady push (Book 2, p. 39) *really* convinces the child in a way that telling him does not. Similarly, most children find it hard to believe that a ball flicked off from a table top and one dropped over the side at the same time will both reach the ground at the same time (Book 6, Unit 3). Understanding that a missile has both a horizontal and a vertical component of motion begins with a sensorimotor experience. (Book 5, Unit 8). And the future student of high school chemistry who has spent time in elementary school constructing models of atoms (Book 5, Unit 6) will find that the theory of chemical bonding comes naturally to him; he can imagine a model of the oxygen atom from his experiences.

Note that each of the activities mentioned helps to correct a misconception or to build a mental image of how something in the physical world *works*. Too much science-teaching time has been wasted in the past on activities with no foundation in an important science concept. Simply building a space station with model rockets in the classroom cannot be justified in terms of its cognitive value. While the activity has motor components, it probably generates more misconceptions than it clears up and contributes nothing to an understanding of the physics of space travel.

Following the sensorimotor experience (or assuming one in some cases), Bruner describes an *iconic* step in concept-building. After "meaning in the muscles," the child must build a mental image of what it is he is acquiring knowledge about. In this series we have aided the development of this step in the type of illustration used in special cases. The first grade pupil is introduced to the concept of a system in equilibrium through a sensorimotor experience with the seesaw. Then *diagrams* of the system are presented, with distance and weight clearly indicated as the variables. The diagram serves the function of giving the child a mental image of the essentials in the system. It is a pared-down version of the illustration showing actual children seesawing. In Book 2, force diagrams are used, again after a sensorimotor experience, to show both size and direction of the force in question. In Book 6, physical experience involved in understanding time-distance relationships is provided in graph making, the end-product of which then serves the image-building function. In Book 6, Unit 1, also, the learner becomes acquainted with vectors and builds a mental image of velocity with vectors.

With the proper sensorimotor and mental-image underpinning, the learner can then go on to deal with a concept symbolically—that is, with language. Like adults, the pupil who has difficulty in understanding the sentence, "The intensity of light varies inversely with the square of the distance from the source," falls back on sensorimotor memories. If he has actually worked out activities involving the inverse-square law, then he has some "feel" for what the term means. If, in addition, he can also bring to mind a mental image of a diagram of the inverse-square law applied to light, then the sentence takes on additional meaning.

Motor activities, mental images, language—all three steps are not necessary for all concepts. For some concepts, pupils bring with them to school a strong sensorimotor, mental-image foundation, and are ready for the symbolic step. But for other concepts, where the foundation has been missing or faulty, one or both steps are essential. With many concepts, as Piaget points out, knowledge is deformed by a purely verbal approach. Teachers are being advised today, in science teaching, as in all teaching, to spend more time to teach what used to be covered in a few minutes with a few verbal statements. The advice is good—provided the teacher picks the right concepts to concentrate on, and provided the extra time is spent wisely on those steps that build readiness for the verbal stage.

# PART III: SOME PROBLEMS OF METHOD IN TEACHING SCIENCE

## PROBLEMS OF MOTIVATION

Psychologists are generally agreed that motivation is the first essential to learning. If pupils are to learn science, they must first *want* to learn; they must be motivated. However, there are a number of misconceptions with respect to how a state of motivation can be induced. Some teachers confuse motivation with external stimulation supplied to interest children in a lesson. Thus one teacher says, "But I have no trouble in getting my children motivated. I just produce a few pieces of equipment and tell the class we are going to have an experiment, and they are all interested."

Readers will agree with the teacher that children are immediately attentive when an experiment is proposed, but teachers will also recognize that interest in observing an experiment does not necessarily lead to motivation to learn important science concepts. The behavior of children who receive chemistry sets for a holiday present is a case in point. Many a child delights in mixing the chemicals and watching the resultant change in color or state of matter, but for too many it is the magical "result" that intrigues, rather than the chemistry of the change.

For the psychologist, however, motivation is intrinsic to the organism. It is no secret that even the very young infant learns spontaneously and enjoys the process. Furthermore, he is motivated to learn even when there is no adult present to supply initial stimulation. A ten-month-old baby who wants a toy that is out of reach on a cushion in his crib discovers that by pulling on the cushion he can bring the toy within grasp. He is learning that one can use tools (the cushion) to extend the arm to reach objects in space. The motivation for the learning came from within.

Teachers, too, can give many examples of intrinsic motivation. In Book 6, in the unit entitled "The Nature of Light," an activity is described involving use of a homemade ripple tank to study the behavior of light waves. Sixth grade children with access to this equipment have been observed before school and in free time, placing obstacles across the tank or inserting sharp-edged rulers below the surface of the water, to see what happens to the waves they create with a dowel stick. Fourth grade children studying electricity hurry to the science table when assignments are finished, to experiment by winding wire around a nail for so many turns to find out the effect upon the strength of an electromagnet. There appears to be a basic urge to explore, to find out how the environment

can be changed, and to learn what consequences flow from these changes. When this motivation to interact with the environment is present, the child carries on activities with considerable persistence, getting interesting feedback from his efforts and acquiring knowledge in the process. In the language of Piaget, the child assimilates and accommodates, restoring mental equilibrium when accommodation has been achieved.

It is not difficult to find examples of self-motivation in pupil behavior. The problem for the teacher, however, is to set the stage so as to produce this kind of behavior. More specifically, it is the problem of how to induce intrinsic motivation so that the pupil learns what the teacher wants him to learn.

Let us consider the case of a fourth grade teacher who is about to teach a unit on sound. Among the concepts that she wants pupils to acquire are: (1) In order for sound to be produced, something must vibrate; (2) For human beings to hear a sound, vibrations must occur between sixteen times and twenty thousand times a second; (3) The kind of sound one hears depends on the number of vibrations. We know that pupils will acquire these concepts through a self-regulatory process, but what can the teacher do, what stimulation can she furnish, to get the process started?

Theorists of learning have identified the elements that make a situation stimulating and that induce intrinsic motivation. One such element is that of novelty. A relatively less familiar situation is more stimulating than the familiar, and human beings (lower animals, too) clearly prefer the novel to the well known. The situation, however, must not be too novel, for too much uncertainty breeds fear and withdrawal.

Some theorists prefer to call the stimulating element "cognitive dissonance." By that they mean that there must be a discrepancy between information already stored in the brain and information coming in from an ongoing experience. When incongruity exists, there is a basic urge to resolve it so that mental equilibrium is restored. A pupil may presently believe that the way to make a stronger electromagnet is to make it bigger; bigness and strength are associated in his mind. Thus he would predict that a heavy spike will attract heavier objects than a slim nail. Faced with evidence that contradicts this belief, he then experiments with nails of various sizes and with various turns of the wire to find out what actually increases the strength of an electromagnet. He acts to get rid of the incongruity and to restore equilibrium.

The problem, then, for the teacher who would induce motivation in children is to provide encounters with objects or situations that will be incongruous with information children already have. To provide such encounters, the teacher must first know where children are in their thinking with respect to the concepts to be taught. If the teacher wants pupils to acquire the concepts we have listed for the unit on sound, then the teacher must first know what the pupils already believe about how sounds are produced and what the pupils believe about the reasons that sounds are different in pitch and intensity.

One way to find out what pupils already believe is to ask them. A teacher can start a lesson with questions based on the concepts to be taught. Thus, the teacher might begin with the question, "What makes a sound?" To such a question the teacher is likely to get an answer like, "There's a sound when we hit something." The teacher counters this response by asking, "Are all sounds made by hitting something? Who can give me an example of a sound that is made without something being hit?" Examples such as shuffling a shoe across the floor, rubbing the desk with the back of the fist, speaking, etc., are incongruous with the notion that something must be hit for sound to be produced, and pupils are motivated to find out what *is* the common element in all of the examples that produces sound. A discussion centered around questions designed to expose the incongruity between presently held beliefs and evidence to the contrary can induce motivation to resolve the discrepancy.

Even better than the purely verbal approach to motivation is one involving motor activity. From the motor activity, a pupil can take in information not only through the auditory sense, but through the visual and tactile senses as well. Instead of using discussion and relying upon words to elicit cognitive dissonance regarding how sound is produced, pupils can engage in such activities as vibrating a ruler over the edge of the desk, snapping a rubber band held between the teeth, or observing dry cereal moving up and down on a vibrating drum top. Such motor activities are better than the verbal because (1) they are more interesting; therefore, pupils will be more attentive; and (2) they permit more information to be assimilated (the actual information input is greater than when discussion alone is used). The advantage of the motor over the verbal is only true, however, if the motor activity can produce enough novel stimuli to be motivating. A motor activity from which the child can perceive only stimuli too elementary for his level of cognitive development is obviously a waste of time.

Throughout *The Macmillan Science Series,* many activities are introduced that are designed to induce pupil motivation. These activities take more class time than a verbal discussion, but teachers are urged to take the time for them. Only as the pupil becomes aware of the discrepancy between what he has believed and the actual evidence he is assimilating from an activity will he be motivated to acquire new knowledge. Assimilation is facilitated by activities that permit a multisensory approach rather than a purely auditory approach.

We can summarize the modern approach to motivation as follows:

1. The teacher must have clearly in mind the concepts the children are to acquire in connection with the study of a particular topic. These generalizations are listed for each unit in the Teachers' Guide.

2. The teacher uses discussion or, even better, a demonstration or individual pupil activity to stimulate pupil thinking about a particular concept.

3. The teacher asks questions or redirects pupils' observations in order to reveal any discrepancy between stored information and informational input.

4. The discrepancy is stated as a problem to be resolved in the course of the lesson.

## PLANNING FOR INDIVIDUAL DIFFERENCES

As in teaching any other school subject, the classroom teacher must plan for individual differences in teaching science. And as is true in other school subjects, individual differences in reading ability create the biggest problem. A fourth grade class of 30 pupils may have a reading range that varies from second to sixth grade ability. How can the teacher accommodate such a range? Teaching pupils in separate groups as is commonly done in reading and arithmetic is not feasible; there is a limit to the number of separate lessons a single individual can teach in a day's time. Nor is grouping within the classroom desirable, except on a temporary basis, for subjects like science and social studies, if each grouping involves a separate body of subject matter. In these subjects there is a core of concepts that should be part of the curriculum for all pupils. All pupils in a particular grade ought to have the chance to acquire those concepts at the level of difficulty possible for them. Some fourth grade pupils may acquire simpler concepts about energy such as "Energy can be transformed from one form to another in order to get work done," while others may tackle more sophisticated concepts such as, "When energy is transformed, the total energy at the beginning and end of the transformation is the same." Managing such a range is quite possible for the teacher.

To provide for the slow readers, it is necessary to find books at their reading level treating the same unit that is being studied by the rest of the class. This is often possible to do in a subject like science, where many of the same topics are encountered in alternate years or every third year. Motion, for example, is studied in grades 2, 3, 5, and 6; weather is a topic in grades 1, 4, and 5; units on living things appear in grades 2, 3, 4, 5, and 6. Other examples of a spiral organization can be found by scanning the complete Table of Contents, which appears in Part IV. Many schools are operating on a flexible plan with regard to the use of texts, taking advantage of the spiral organization in order to meet individual differences. A sixth grade teacher, for example, who has pupils who are retarded in reading, borrows from the third or fourth grade for the particular unit being studied. She introduces the unit in exactly the same way to the entire class, but after pupils have completed their differentiated reading assignments, she introduces into the class discussion some questions aimed at the less sophisticated concepts covered in the easier book. This part of the discussion serves as a review for pupils who are more advanced in concept development. At the same time, the slow learners have the advantage of seeing the demonstrations and following the discussion of harder concepts, all of which serves as readiness for acquiring the concepts when they are encountered later on. As every teacher knows, it is often the *second* explanation that makes assimilation and accommodation possible.

But what does the teacher do in the case of units *not* covered in an easier book? One solution is to vary the reading assignment, requiring slow readers to read less material. Some teachers work with the slow readers as a group, having the material read silently in small sections and its meaning discussed at the end of each section. Under no condition should a pupil be given a book that is beyond his comprehension, unless special help is also provided. Nothing will stifle pupil interest in science more quickly than a teacher who requires the class to read books that are too difficult. As is true both in social studies and in science, the content lesson is also a reading lesson, and the same principles of reading that hold true when pupils are using readers are valid when pupils are reading science texts.

Of particular importance to slow readers are activities and experiments. Slow learners need even more in the way of sensorimotor experiences than do fast learners. The slow-learning third grade pupil can learn the concept of force only by actually setting objects in motion under varying conditions. There is a temptation because they read so slowly to have slow learners spend more time on reading and less on activities. Reading assignments, however, should be adjusted for these pupils so that they also have time to engage in experimentation.

In the past decade, much has been written about the gifted child and about the necessity of providing him with challenging situations. A great deal of effort has been expended in the direction of providing enrichment activities. Unfortunately, however, so-called enrichment activities too often involve only *busy work;* that is, the activity keeps the child *busy,* but at exactly the same cognitive level that he has covered so far. A bright child can be kept busy working on an animal chart on which he lists animals, names of the baby animals, and where the animals live, but at the same time the activity may offer nothing in the way of intellectual challenge. The gifted child needs enrichment in *depth,* rather than horizontal enrichment. He ought to have the chance to tackle intellectually challenging problems that will lead to the acquisition of concepts more sophisticated than those to which the rest of the class is exposed.

If we agree that the gifted child should have enrichment in depth, the next concern is how to provide it. Because the bright pupil is a good reader, some teachers are tempted to keep him busy with special

reports. He is the person assigned to look up topics in encyclopedias or other reference books; but such assignments are all too frequently carried out by copying lengthy excerpts from the source. Special reports need not, of course, be pedestrian or routine. A book such as *King Solomon's Ring*, by Konrad Lorenz, with its fascinating observations of animals, not only brings additional knowledge to the bright pupil in the fifth or sixth grade who reads it, but is likely also to inspire him to observe systematically his pet goldfish or dog, the birds in the backyard, the squirrels in the park, and other animals in his environment. But all science study cannot be carried on only through vicarious activities; directed observation and experimentation, to discover more advanced concepts or to apply acquired concepts to more difficult problems, should also be encouraged in the bright pupil.

Let us examine two different activities proposed in connection with the study of the unit entitled "How Animals Behave" (Book 6). One activity asks that the student find the answer to the question of whether differences between species or differences between breeds of the same species are greater. Pupils are instructed to carry on a series of observations on dogs and cats—recording the animals' approaches to food, their manner of eating, and their behavior after the food has been eaten. By selecting various breeds in each category, comparisons across breeds as well as across species can be made, and data can be gathered to answer the question. The activity serves as reinforcement for key ideas covered in the text; it is one that can be carried out even by slow learners who, hopefully, will become more aware of similarities and differences in animals. It is structured carefully so that directions can be followed easily. Note that alternative answers to the question under investigation are suggested: either the differences across species or the differences across breeds are greater; the problem for pupils is to find data to support one of the two possibilities—an easy task even for the slow learner.

Now let us examine a second activity suggested in connection with the unit "How Animals Behave." In this activity, the pupils are asked to select a category under which observations of animals might be collected—moving-about behaviors, courting, nesting, taking care of the young, and signaling. First the pupil must decide which category and what questions he will seek to answer about that category. Here, we will be concerned only with the "moving-about" behaviors of animals. A pupil might ask, "What is the effect of temperature change upon behavior? Do animals move faster or slower when the temperature rises?" To find the answer, the pupil must vary temperature conditions, choosing animals such as ladybugs, earthworms, or ants, which would be easy to collect and work with. He must plan and construct a temperature box, perhaps heating one end with an electric bulb while the other is left at room temperature or chilled by a tray of ice cubes. Next he must put the animals into the center of the box and observe their behavior. Then he must use his observations and those of his classmates to *discover key concepts* about moving-about behaviors, checking out the particular variable he has selected for testing and perhaps noting other variables worthy of trying out.

Note that this activity is not structured step by step for the pupil. He is not given a choice of hypotheses for testing; he must use his logical reasoning powers to figure out what is worthy of testing. Nor is he told what to do to test his hypotheses; the plan for experimentation will be a product of his own creativity.

Such an activity can provide the challenge to which bright pupils respond. When they first begin to do independent experimentation, they will need help. The teacher must teach them the process—how to select the variable for testing, how to set up adequate controls, and how to collect data.

To summarize, activities and experiments that place a high premium on logical reasoning and creativity must be provided for gifted pupils. Enough

help should be given so that they do not flounder, but they should be allowed independence in working out solutions to problems.

### School Organization and Individual Differences

In recent years many innovations in the organization of the elementary school have been effected to take care of individual differences. Nongrading, team teaching, and dual-progress plans are three such innovations. No attempt will be made here to weigh the advantages and disadvantages of each plan; we will merely point out implications of each plan for the teaching of science.

In the nongraded school, grade labels are removed, and children are assigned to a teacher according to reading level. Thus one teacher of 8-year-old children might have an accelerated class capable of reading fourth grade books, while another, with a slow-moving section, might have pupils reading at the second grade level. Homogeneous grouping, whether on the basis of intelligence test scores or reading ability, has always had an appeal for teachers; teaching would be so much easier and more effective "if only individual differences could be taken care of by some kind of administrative device." Unfortunately (or fortunately, depending upon one's viewpoint), they cannot be. In an accelerated class of 8-year-olds, all the children may be able to read easy fourth grade books, but some can read fifth grade books and some do even better. The teacher must still cope with the problem of providing for those children who are capable of doing more advanced work.

A practical method of obtaining appropriate reading materials is to borrow books on the same subject from higher grades. Many teachers are reluctant to do this for fear that the teacher of the higher grades may say, "But what will they read when they are in *my* room?" The problem is one of coordination within a school so that plans are formulated to enable pupils to encounter challenging materials each year. In many schools, teachers pass along a list of the texts read in one year, so that the next year's teacher can plan realistically. In place of assigning texts according to average reading level, as is commonly done in nongraded schools, a teacher can select texts that will take individual pupils higher on the reading ladder. In place of a single text at one grade level, a teacher will have two or more levels to use with a class. Junior high school texts may be introduced into accelerated classes of twelve-year-olds if the need occurs.

Nongrading is a vertical form of organization of the elementary school; team teaching represents a horizontal form. In some schools, team teaching differs little from departmentalization, with different teachers who work as a team assuming the responsibility for teaching different subjects to the same children. As originally conceived, however, a team consisting of a master teacher and several assistants would be responsible for the instruction of about sixty children. The master teacher in a fourth grade might make a presentation to the whole group or conduct a demonstration, while assistants working with no more than fifteen children would supervise reading assignments and follow-up activities.

Team teaching offers certain advantages for science instruction, particularly in its provision for small-group work. The ratio of one assistant to fifteen pupils means many more opportunities for pupil participation in asking and answering questions and in engaging actively in experiments. Whether or not such opportunities are utilized depends, of course, on careful planning by the team. The practice of giving large group lectures or demonstrations, however, needs to be examined critically. It is a rare teacher, indeed, who can hold the attention of large groups of immature pupils for the length of a science lesson. Where team teaching is in vogue, it is better to confine the whole-group sessions to demonstrations requiring

much time to set up; these sessions should have a fast enough pace to ensure maximum pupil attention.

The dual-progress plan—another plan of organization—organizes the school both horizontally and vertically. For children above the third grade, the day is divided into two parts: graded and nongraded. Pupils spend the graded half of the day with a core teacher who teaches language arts and social studies. During the nongraded half of the day, subject-matter specialists take over, including one for science and arithmetic. For special subjects, children are grouped not according to age or grade, but according to aptitude, interest, and achievement. A fourth grade pupil, for example, if science is one of his strengths, might find himself with older children in the science class. For special subjects in which he is weak, he might find himself with younger children. Thus the plan provides for intraindividual variability—a distinct advantage in teaching a subject such as science where talent may become evident in the intermediate grades. An additional advantage is that the special teacher is usually better prepared in the subject matter and therefore presumably able to do a better job of building concepts.

## TEACHING SCIENCE TO CULTURALLY DISADVANTAGED CHILDREN

There are teachers in both rural and urban areas of the United States whose classes consist almost entirely of children of the poor. These children present special learning problems, for their impoverished environment has not provided experiences that help mental structures to develop and intelligence to grow. Their homes lack the toys, books, pencils, paper, and mechanical equipment that offer opportunities for discovery. Their parents, themselves disadvantaged as children, lack the knowledge and skills, as well as the facility with language, to call children's attention to phenomena or to answer questions and raise problems; thus, it is difficult for them to furnish their children with science information and to make the children more curious about the world.

In his day-to-day living, the middle-class child has countless experiences that provide readiness for science. His picture books provide training in observation, sharpened by the mother's comments as she calls attention to details of size, color, shape, and cause-and-effect relationships. He takes a bath and observes floating objects in the tub. He goes for walks with parents who comment on shadows, budding trees, a squirrel's nest, how a woodpecker gets its food, and what the position of the sun in the sky tells us about the approach of suppertime. By the time he enters school, the middle-class child has developed mental structures upon which he can draw for solutions to new problems. The lower-class child, lacking the simple mental structures because of environmental limitations, often cannot grasp the more difficult problems with which he is confronted.

There are three ways in which the teacher can help to compensate for a child's impoverished background. First, the teacher must provide a rich language environment for the child. Language facilitates the development of logical thought. A child who doesn't know the names of domestic animals as common as "cow" is obviously going to have difficulty in learning the concept of "animal." A child who lacks the vocabulary to describe dimensions is not going to be able to deal adequately with the notion that as one dimension gets longer, another gets thinner.

The first two books in *The Macmillan Science Series* are illustrated profusely. The teacher can use the pictures to build vocabulary. The teacher can supply labels not only for objects but also for the properties of the objects—shape, color, texture, size, and weight. The teacher can introduce comparative terms such as "taller than," "heavier than," "darker than." The teacher can teach the terms to describe length, width, depth, weight, and other dimensions. The child who knows the terms is more aware of properties of

objects in his environment, and these can help him progress beyond the stage of sizing up an object in terms of whatever variable stands out perceptually.

Beyond the primary grades, the teacher must continue work on vocabulary development. Interestingly enough, it is not the technical vocabulary (e.g. "atom") that presents a problem (provided, of course, the teacher presents the technical terms with proper background); it is the vocabulary to carry on ordinary life activities, which should have been built during the early years, that is lacking. The child learns "pendulum," but he doesn't know the phrase "back and forth" to describe its movement. Getting children to talk about what is going on as they carry out experiments reveals these deficiencies. To counter this situation, the teacher can supply the terms, have the child use them, and review them in context from time to time.

The second recommendation for teaching science to culturally disadvantaged children is to provide more, not fewer, sensorimotor experiences than for middle-class children. The culturally deprived child cannot learn science solely by reading about it. He does not bring to the written word a reservoir of cognitive structures built up out of firsthand experiences. To understand the physical world, he must act upon it. There are 9-year-old culturally disadvantaged children who are *not* mentally retarded, but who do not know that if someone drops an object into a glass of water, the water level will rise. It is not enough for the child merely to read about the effect of one's actions; the child must experience it firsthand, assimilating information directly from the activity. Thus, in Book 2, if the disadvantaged child is to understand gears, he needs to use an eggbeater (a new experience for most children of that age) and observe how the gears are used to turn the beaters. Even more important, he needs to construct models of physical processes. As he makes and operates the endless belt described on pages 54 and 55, Book 2, he can see how, when one wheel is turned, the belt is made to move. He can see the force of the first moving wheel carried to the second. Such an experience builds the cognitive structures necessary to comprehend how a force is passed from one part of a machine to another part some distance away, and how twisting the belt into a figure eight makes the wheels turn in opposite directions and so changes the direction of the force.

Teachers will find additional activities included in the teaching suggestions at the sides of each page of text. Those involving actual motor activity are particularly appropriate in compensatory education.

The third suggestion for helping disadvantaged children is to build up their background of general information. Even at age 10, these children, in response to questioning, are likely to say that a duck is not a bird because ducks can't fly, and that birds and ducks can't be related because birds don't swim. Children can glean a great deal of general information from attractive picture books that are placed on the science table. One fourth grade child very nicely solved an animal-classification problem on the basis of information assimilated from picture books. As he put it, "I know ducks are birds because I could see in the pictures that there were some things the same, and I figured out that if it's got feathers and wings it's got to be a bird, and it doesn't count if it doesn't fly." In Piaget's language, equilibration occurred; the boy had given up an earlier, erroneous notion and accommodated the new information being assimilated.

Note that in all of the examples cited above there are opportunities for furthering logical development. The teacher can emphasize whole-part relations when discussing pictures with children. Relative terms such as "longer than" and "thinner than" aid children in understanding that a change in one dimension may be compensated for by a change in another, with resulting conservation. Testing of disadvantaged children at the University of Illinois reveals that they are lower on tests of logical development than middle-

class children. Compensatory education must include special attention to ensure the optimum development of logical processes in disadvantaged children.

## FIELD STUDIES IN SCIENCE TEACHING

Science becomes meaningful for children only as it helps them interpret their environment. Classrooms, science books, audiovisual materials, and laboratory equipment are not the only means by which this purpose is to be achieved. At best they represent the beginning of the process. Ultimately, what is learned from a science book, a motion picture, or a laboratory demonstration must be applied or used in situations beyond the classroom if it is to have permanent educational value. Field studies are planned learning activities that take place outside the classroom.

Teachers often assume that once a science concept is dealt with in the classroom, pupils will use it on their own for out-of-classroom activities. It is possible that a few may do so, and rather extensively. Some may use the concept on a relatively limited scale. But many of the pupils may never relate the pertinent concepts to the things that are happening about them. For example, in a unit on conservation, pupils may read about ways in which runoff water erodes unprotected soil. They may view a film that shows the process taking place. They may even do a classroom experiment to measure the soil eroded from protected and unprotected surfaces by a measured quantity of runoff water. But what happens when the pupils *leave* the classroom? Do they recognize places where soil is being eroded? Do they suggest ways in which the erosion can be controlled? More important, do they attempt to do something about it? If the science of soil conservation is to become meaningful to pupils, learning about it must extend beyond the classroom into actual situations where the phenomena are taking place.

After considering the question of how science concepts dealing with soil conservation should be made more meaningful to pupils, a teacher might decide that three types of field studies would be appropriate.

One type has to do with locating places in the schoolyard or in nearby spots where soil is being eroded. Before the pupils started on their search, the teacher would alert them to the kinds of evidence that indicate that soil is being eroded. These include soil that has been washed onto sidewalks, roots of trees that have been exposed by the erosion of soil, small gulleys showing that erosion has started, and deltas of soil that have been deposited by water. After pupils had learned how to spot the evidence, they would proceed as a class or in small groups to locate places of erosion in the area. Following the group activity, pupils could be asked to look for other places near their homes and report their findings to the class.

A second type of field study might be to select one of the places where soil erosion is taking place and plan ways of stopping it. Ideally, this should be a place near the school where everyone can take part. Some pupils might undertake individual control projects in their own communities.

A third type of field study might be to visit a place where a planned procedure is being used on a large scale to control soil erosion. This might be a farm, a public park, a housing development, or new highway construction. The persons who are responsible for the plan would answer pupils' questions.

Based upon the above descriptions of three types of field studies having to do with soil erosion, it is reasonable to expect the following educational purposes to be accomplished by such activities:

1. Reinforcement of science concepts taught in the classroom by observing the concepts in action.

2. Development of the habit of viewing the environment in the light of concepts introduced in the classroom.

3. Recognition of situations that represent problems in need of solution.

4. Personal involvement in solving such problems and the development of the required skills.

5. Acquaintance with efforts to deal with such problems.

6. Acquaintance with agencies and people who assume responsibility for the problems in question.

There are a number of matters that must be considered when using field studies in teaching elementary school science.

### Background Preparation

Generally, it is desirable to develop the pertinent conceptual background before undertaking a field study. In the above examples, reading about soil erosion and its causes (Book 3, "Our Planet Earth"; Book 6, "Life on the Earth"), viewing a film that shows how the process takes place, performing experiments to determine the effectiveness of plant cover in reducing erosion, and discussing the facts involved would help to build the essential conceptual background for the three field studies. This would give children the "eyes" with which to observe and interpret their observations.

### Comprehensiveness of the Field Study

The field study should not be so comprehensive that teachers and pupils "get lost" in carrying it out. In the above examples, there were three distinct, manageable phases involved. Each phase had a specific purpose to accomplish. The first phase had to do with locating places where soil erosion was taking place. The second was the selection of one of these for further study. The third was finding out how other people solve the problem on a larger scale.

Wherever possible, the field study should provide for a personal commitment from each pupil. In these studies each pupil was encouraged to locate places where soil erosion was taking place in his neighborhood and to share his findings with the class. In addition to work on the class control project, individual pupils were encouraged to undertake small-scale control in their own neighborhoods.

### Preplanning

Preplanning can pay high dividends in accomplishing the specific purposes of a field study. There are two aspects to preplanning: the teacher's preplanning by himself and the preplanning that the teacher does with his pupils. It is reasonable to assume that preplanning on the part of the teacher would lead to the decision to conduct the three field studies in the sequence described earlier. He would be responsible for planning and making decisions regarding the feasibility of various approaches to each study. He would also have the responsibility for making administrative arrangements. He would then involve his pupils in planning the details.

Prior to the first field study (that of locating places where erosion had taken place), the teacher and pupils would work together in deciding upon the kinds of evidence that they would look for. They would make plans for recording the evidence and indicating the places where the evidence was found. They would plan how to proceed from the classroom to the places they were going to visit. They would plan how the time allotted for the study would be used.

### Field Studies as Investigations

Field studies should be carried out as investigations rather than as idle excursions away from school.

To be an investigation, a field study must have a clearly defined purpose. Although children will use many skills, such as those involved in communicating, observing, comparing, classifying, interpreting, and evaluating, the development of these should not become the primary purpose of a field study carried out as an investigation. Its purpose should be to obtain information and/or to solve a problem.

In the first field study on soil erosion, the purpose was to locate places where erosion was taking place. In the second, it was to suggest ways to control erosion in one of the locations. In the third, it was to find out how erosion is controlled on a large scale. The purpose of each investigation should be made clear to all who are involved in it. Each activity in the investigation should relate clearly to its purpose.

Where investigations involve the collection of specific data, plans should be made for recording them in an organized manner. The organization will be determined by the manner in which the data are to be used. For example, if the field study is to locate places where soil is being eroded by runoff water, a decision will have to be made regarding the area to be explored. Suppose it were limited to the school grounds or to a vacant lot near the school or to a three-square-block area adjacent to the school. Before the exploration was begun, a decision would have to be made regarding the method of recording the sites of erosion once they were found. In this case it would be reasonable to use a mapping method. A map would be drawn of the area. The map would be duplicated and each pupil given a copy. As erosion sites were found, they might be located on the map by placing an X at the appropriate spots. Some legend might even be used to indicate how severe the erosion was at the different sites. These data could then be referred to in selecting the one area that would become the test site for the control study.

Where the investigation has to do with solving the erosion problem in one of the places, other methods of recording data might be used. First, a record should be made of the nature and extent of erosion at the selected site. Next, the method by which the erosion is to be checked should be recorded. Finally, the report should be concluded with statements regarding the apparent success of the method used.

Where the investigation has to do with finding out what methods are used to control erosion on a large scale, the data would probably be recorded as answers to a list of questions prepared before the trip was taken to the site. Different pupils might be given the responsibility for obtaining answers to certain of the listed questions. After the answers were obtained, the study would be concluded by a written report that explained a method of controlling soil erosion on a large scale.

Each investigation should culminate in something that represents a record of what was accomplished as a result of the investigation. Investigations should run full cycle, from purpose back to purpose. The findings of the field study should be reported in ways that show how the purpose of the field study was accomplished.

### The Size of the Group

Where it is impractical for the entire class to participate in a field study, a similar group of pupils or an individual pupil might conduct the study for the class. Suppose that the problem of transportation to the site where large-scale soil conservation was being practiced precluded the possibility of the entire class's making the trip. The teacher or one of the parents might take one or more pupils to the site. They could obtain answers to the questions that the class had prepared. Arrangements might even be made for them to take pictures to illustrate the various practices. These could be used in making a report to the whole class.

There are various ways in which teachers can learn about the types of field studies that might be

carried out by their pupils. In *Science for Tomorrow's World,* field studies are suggested at appropriate places in the pupil's text and in the Teachers' Annotated Edition:

BOOK 1
Visit a pet shop (p. 99).

BOOK 2
Compare the warm and cool ground outside your school or house (p. 111).

BOOK 3
Visit a planetarium (p. 35).
Plan a trip to a museum (p. 89).
Visit a food market or a farm (p. 219).

BOOK 4
Visit a public library (p. 131).
Visit a fire station (p. 309).
Visit a water purification plant (p. 314).

BOOK 5
Visit a botanical garden (p. 75).
Visit a drug company (p. 163).
Visit a textile factory (p. 208).
Visit a weather station (p. 261).

BOOK 6
Visit an electric utility company (p. 140).
Visit an astronomical observatory (p. 190).
Visit a biome (p. 296).
Visit a zoo (p. 341).

The soil erosion field studies described earlier come from this source. Generally, schools which have detailed courses of study include field studies among the suggested learning activities. *Science and Children,* published by the National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D.C., is designed primarily for elementary school teachers. Each issue contains articles that include out-of-classroom activities in elementary science.

Some school systems supply teachers with guides to sites in the community where field studies may be conducted. These guides include such information as:

1. Name of site.
2. Location and directions for reaching it.
3. Age level for which its use is best suited.
4. Science topics to which the use of the site is related.
5. Data which might be obtained at the site.
6. Specimens or materials that could be collected.
7. Times most suitable for visiting.
8. Person with whom arrangements should be made.
9. Special regulations.
10. Safety factors to consider.
11. Evaluation statements made by those who have previously visited the site.

Sometimes good ideas for field studies can be obtained by talking over the problem with other teachers, especially secondary school science teachers. Finally, elementary school teachers should not underrate their own creative imagination in discovering field studies that will add a new dimension to their science teaching.

## Evaluating Field Studies

After the field study is completed, it should be evaluated by teacher and pupils. One of the first questions to ask in evaluating a field study is, "Did it accomplish its purpose?" Where it failed, the next pertinent question is, "Why?" The answers to this latter question then become clues to the safeguards that should be exercised in the next field study.

Suppose, on their first soil erosion field study, children failed to find the evidences of soil erosion that had been anticipated by the teacher. This might indicate that the teacher had not done a careful job in selecting the area to be studied. It might mean that the children had not been properly briefed regarding the kinds of evidence for which to look. It might also mean that, for one reason or another, pupils had not observed carefully enough.

Suppose, on their second field study, the plan developed by the pupils did not control the erosion. This might be accounted for by the fact that they had not considered all causative factors and thus had not provided controls for some of them. It might also be that the plan was a good one, but they failed to carry out some phase of it.

Both teachers and pupils experience great disappointment when projects such as field studies do not turn out as expected. Both are tempted to forget the whole thing and to go on to something else. But there is always a reason for things not turning out as expected. To find the reasons and to carry out another study is an equally important educational experience. From it, pupils learn that one must have as many pertinent facts as possible before making his plan, and furthermore that his plan should take all pertinent facts into consideration. Finally, the pupil learns that the study must be carried out in terms of each detail of the plan.

### Local Conditions

The use of field studies has to be adapted to local conditions. One local condition has to do with the availability of sites. The soil erosion field studies described earlier are those that could be carried out in most school situations. Even for schools located in cities where there are asphalt-covered playgrounds, the teacher and class should not have to go far from school to find a vacant lot or a small park area where soil is exposed. And wherever soil is exposed, there will be erosion. Somewhere, in practically every community, new buildings or houses are being constructed. Highway construction is taking place across the country. In these places, soil is being exposed to erosion.

### Records of Field Studies

A file should be maintained of all completed field studies. The file, prepared by the teacher, might consist of one-page summaries of each field study, supplemented by a copy of one of the better reports written by the pupils. The teacher's summary should include the following information:

1. Purpose of the field study.
2. The science unit to which it is related.
3. The site and person with whom arrangements were made.
4. The number of pupils involved.
5. Persons who assisted with the study.
6. The date the study was begun and the date it was completed.
7. Problems encountered, along with notes as to how each problem was handled.
8. What pupils learned from the study.
9. Points to keep in mind in planning another, similar study.

Records such as these will be helpful not only in future planning of field studies, but also in sharing ideas about field studies with other teachers. The sharing might be in your own school or with many elementary school teachers through an article written for a journal such as *Science and Children*.

## USING THE COMMUNITY

There are a number of good reasons why teachers should make maximum use of their communities in teaching science. The ways in which science relates to the lives of people can be effectively demonstrated by activities taking place in the community. In many communities there are people who are uniquely qualified to serve as authoritative sources of scientific information pertaining to many of the topics studied in class. Local institutions such as libraries, museums, planetariums, parks, zoos, and aquariums have been established as sources of information not usually available elsewhere in the community. Finally, through proper use of community resources, the people involved become better acquainted with the educational program of the school and the ways in which teachers are attempting to implement it. This is particularly important in elementary science, because science was not taught in the elementary school when many of the community's adults were pupils themselves.

### Environmental Resources

Science teaching should begin with the ongoing experiences of children. It should move to other experiences from which children can gain more sophisticated insights or concepts. Finally, the new concepts should be used to reinterpret aspects of the immediate environment. Science then becomes a way of making the environment more meaningful.

The child's immediate environment is the community in which he lives. It is both a natural environment and a man-made environment. His natural environment includes the sky above him, the nearby woods and fields, streams and ponds, rain, wind, sunlight, clouds, snow, rocks and soil, plants and animals, and other people. His man-made environment includes school buildings and houses; bicycles, automobiles, trucks, tractors, and airplanes; highways, railroads, and streets; telephones, radios, and television; rockets and spacecraft; filling stations and airports; stoves and refrigerators; baseballs and bats; factories and stores; and even merry-go-rounds and Ferris wheels. Such an analysis as the above could be extended almost indefinitely. What is indicated is that the community represents a laboratory with almost unlimited resources for teaching science. In fact, the environmental resources in any community are so extensive that teachers may find it difficult to know where to begin.

### Application of Concepts

You could begin by writing the title of each unit in your science text on a separate sheet of paper. Under each title, list the topics that are dealt with in that unit. Next to each topic, list activities in your community that might be used in helping to teach the concepts with which the topic deals. Here is an example of how this might be done for some of the topics in a unit on forces (Book 4, Unit 2):

**UNIT: FORCES**

| *Topics* | *Community Activities and Objects to Which Concepts Apply:* |
|---|---|
| Making things move | Men loading a truck by hand;<br>Men shoveling gravel;<br>Hoist used by a construction gang working on a building. |

| | |
|---|---|
| Forces of different sizes | Bulldozer digging a basement for new apartment houses;<br>Car lift at a local filling station;<br>Automatic door-opener at a supermarket. |
| Measuring forces | Scales used in weighing baggage at an airline terminal;<br>Scales for weighing trucks at inspection stations on highways;<br>Scales for weighing children in the nurse's office;<br>The recorded weight tests of fishing lines sold in a sporting goods store;<br>Testing air pressure in tires at a filling station;<br>Posted load limits on bridges;<br>Posted load limits on elevators;<br>Anemometer at a weather station. |
| Keeping things from moving | Brakes on automobiles;<br>Prop reversal for slowing down airplanes;<br>Retaining walls on the side of a steep hill;<br>Plant cover to prevent soil erosion. |
| Balancing forces | Sanding icy streets;<br>Supports on a stepladder;<br>Timber braces in a mine;<br>Supporting trees to protect from high winds;<br>Bicycle stands;<br>Door stops;<br>Umbrella stops;<br>Scaffolding to support workmen. |
| Forces have direction | Weather vane to indicate direction of winds;<br>Hitting a baseball, a tennis ball, or a golf ball; throwing a baseball or a bowling ball; shooting baskets. |

| | |
|---|---|
| Going faster | Roller coaster;<br>Streamlined cars;<br>Skiing on steep slopes. |
| Changing directions | Steering wheels on automobiles;<br>Rudders on airplanes;<br>Handlebars on bicycles. |

These are only a few local examples of how certain science concepts are applied. As you search for others, many more may be found. Once the searching process is started, pupils should be encouraged to take part. As pupils find additional examples, the meaning of the concept will become more firmly established in their minds.

### The Community as a Source of Problems

The community not only provides many examples of how science concepts are being applied, but it is often a source of problems that require science for their solution. Here is an example of how one class became involved in an interesting local problem. At about the time the class had completed their study of a unit on conservation, an editorial dealing with the disposition of unsightly junked car bodies appeared in the local paper. The editorial proposed that the bodies be dumped into one of the Great Lakes—Lake Ontario. According to the editorial, this would remove an eyesore from the landscape and at the same time provide cover at the bottom of the lake for fish. In fact it was reported that local fishermen were in favor of the proposal.

Since pupils in this science class had learned about the importance of conserving metals, such as those used in making car bodies, they felt that the plan would be a waste of mineral resources. They believed it would be much better to reclaim the metal, and so they decided to write to the editor of the paper about their opinions. But their teacher encouraged them to check all of the facts involved in the situation before they wrote the letter.

A clipping of the editorial, along with an explanation of what the science class proposed to do, was sent to the United States Department of the Interior for evaluation. An assistant secretary of the Department replied with a two-page letter. Two paragraphs from his letter are quoted below:

> *With respect to the disposal of automobile bodies, it should be recognized first of all that the major part by weight of a junked car—the chassis—is very largely reclaimed, either for used parts or for steel furnace feed, before the unsightly body shell arrives in a so-called automobile graveyard. These shells have little or no reclamation value for several reasons. First, enormously expensive machinery must be maintained at the waste dealer's yard in order to compact the bulky shell into a form that can be charged into a furnace; second, a serious smog problem is involved in burning out organic material like upholstery before the compacting can take place; and third, the extensive electrical systems in modern automobiles introduce enough copper wiring in the shell to degrade the iron and steel reclaiming in smelting. The net result is the absence, in most instances, of a profit incentive for scrap dealers to reduce automobile bodies to a form saleable to steelmakers in competition with metal derived from cheap and plentiful iron ore.*

*Disposal of automobile bodies in the Great Lakes raises other problems. The Department's Fish and Wildlife Service reports that auto bodies have been dumped offshore into salt water apparently without harmful effects, but without much benefit to the fish because the bodies tend to fill with silt and to lose form through rapid rusting. This Service notes, however, that disposal in the fresh water of the Great Lakes poses other objections, in particular, the absorption of the water's oxygen, during the rusting process, from waters already seriously deficient in this gas for the support of valuable aquatic life because of other wastes.*

It is quite obvious that both the teacher and his pupils, through becoming involved in this community problem, had their concepts of conservation practices, as well as the science involved, extended considerably beyond the unit on conservation that they had studied. In addition, the pupils learned that one should get all the evidence before making a decision about a problem such as this one. At first the problem appeared to be a relatively simple one, with a clear-cut solution. However, it turned out to be much more complex. Finally, they learned how government agencies, such as the United States Department of the Interior, can be sources of information.

## Resource People in the School and Community

In some schools, files are kept of the names and addresses of persons in the local community who may be used as resource persons for various purposes. These generally include teachers and other persons in the school. Where a school does not have such a file, it would be well to start one. A good place to begin would be with those who could be used as resource persons in the elementary science program.

In addition to their professional teaching competence, there often are teachers in school systems who have had other experiences that qualify them to serve as resource persons in elementary science. Included among these would be experiences in outdoor recreational activities such as hunting, fishing, bird watching, stargazing, boating, mountain climbing, and swimming; industries such as farming, manufacturing, lumbering, mining, construction, and transportation; institutions such as hospitals; agencies such as the Forest Service, National Park Service, and Conservation Service; and hobbies such as photography, radio, aviation, and even rocketry. There are people, other than teachers, in the community who have had experiences such as those enumerated above and who may be more available during school time. To find all of them becomes quite a problem. In some schools the P.T.A. takes on the job of locating them. This is generally done by sending out a suitable questionnaire to the patrons of the school. Where such an organized search is not possible, teachers may have to rely upon their pupils and other persons in the school to help locate resource people in the community.

Usually there are a number of professional people in communities who, by virtue of their professions, potentially qualify as resource persons in science. These include scientists, engineers, doctors, and nurses. There are others whose business or work may qualify them as resource persons. These include airplane pilots, firemen, laboratory technicians, food processers, manufacturers, builders, and automotive mechanics. A good way to locate others in this latter category is to examine the classified telephone directory of your community.

## Museums as a Community Resource

If your school is located in a community that has a museum, you will surely want to use it as a

resource in your science teaching. Your school may have an inventory of the museum facilities available for school use. If it does, you should examine it to determine which ones would be suitable in your science course. If it doesn't, you can write to the curator of the museum for such information. Here is a partial list of exhibits listed in the general guide to one rather large museum:

Minerals and gems
Fossil fish
Dinosaurs
Ice age mammals
Insects and spiders
Fishes
Amphibians and reptiles
Birds
Mammals
Animal behavior
Man and his origin
The natural history of man
Ecology
North American forests

From a list such as this, you can select the two or three which you think might be worthwhile for your pupils to visit. Next, you should visit the museum to find out more about the exhibits you have selected. When you do this, plan to spend sufficient time to make a reasonably thorough study of each exhibit. Take notes on points of particular interest.

There are two ways in which you can get your pupils to the museum. Probably the best way is to arrange to take them yourself. If you do, have several parents accompany you to assist in supervising the children. Another way is to encourage parents to take their own children. Whichever way is used, some time must be spent in preparing the children for what they are to observe and how they are to observe it. This is where you will make use of the notes taken during your earlier visit to the museum. From these notes, you can prepare a statement regarding the general nature of the exhibits to be visited and how they are related to concepts that pupils have been studying, or will be studying, in science. Specific suggestions of what to look for should be given. These might be formulated as questions to be answered as students observe the exhibit. If you use the question technique, avoid making a large number of detailed questions. Long lists of such questions often result in children's not seeing the forest for the trees. For each selected exhibit, try to decide on the two, three, or four most important ideas with which it deals. Then formulate questions that will highlight the ideas. Regardless of whether you take your pupils or their parents take them, their preparation for the trip will be much the same. It is doubtful that children can experience anything but confusion from an unselective, unplanned, and unstructured trip to a museum. After the museum trip, there should be a time at school for review and summary of what was learned.

### Planetariums as a Community Resource

In planetariums, a projector is used to display the movement of heavenly bodies on a hemispherical, or bowl-shaped, ceiling. The projector can be set to show how the heavenly bodies appear to rise in the east, move across the sky, and set in the west. It can also be used to show how the stars appear to an observer on the earth at various locations from the equator to the poles. Methods of locating constellations and prominent stars within them can also be demonstrated.

If there is a planetarium in or near your community, encourage your pupils to attend one of the demonstrations. Obviously this should be done near the time that they are studying about stars and planets in their science class. Since the director changes the planetarium show from time to time, you should try to keep informed about the current shows.

Planetariums usually arrange special showings for school-age children. It might be possible for you to combine a planetarium trip with a museum trip on the same day. As was the case for museum trips, children should be prepared for their visits to the planetarium. Admission fees are usually charged. However, special rates are given for school groups.

### Parks as a Community Resource

Parks serve a number of functions in many communities. They are places where people may go for rest and recreation in natural surroundings of trees, shrubs, grass, streams, and ponds. They are places where people may go to learn more about the living things contained within the park. Parks generally contain a greater variety of trees and shrubs than may be found in any other place in the community. They can thus be used by teachers and pupils to observe various types of plant life and to identify similarities and differences among them. Parks can be used in the spring, summer, fall, and winter to demonstrate how the vegetation changes with the change in seasons. Parks usually have ponds or lakes that serve as a refuge for water birds such as ducks and geese. Because they are protected, the birds have become less afraid of people and can be observed from close quarters. Pupils can observe the forms and shapes of their bodies, their eating habits, and the manner in which they walk, fly, and swim.

### Zoos as a Community Resource

From the point of view of children, zoos are among the most popular institutions in communities where they are maintained. Children enjoy observing animals. Visits to the zoo can become significant educational experiences in science if they are properly planned. In planning a trip to the zoo, teachers need to know what animals are kept there, from where the animals were obtained, and how they are cared for. This information can best be obtained by teachers visiting the zoo and having the educational director give them a conducted tour. For a group of teachers, the director may even include a "behind the scenes" tour of the zoo. On such a tour, teachers will be shown how food for the animals is selected and prepared, how animals are treated for injuries and sickness, how cages are cleaned, and how animals requiring special kinds of environments are protected. With background such as this, teachers can plan the zoo trip with their pupils so that it becomes an integral part of their study of science.

### Institutional Aquariums as a Community Resource

Institutional aquariums are more difficult to maintain than zoos and, therefore, are not as common. But where they are maintained, they should be used by teachers to reinforce and extend science concepts related to the variety of living things and how living things are adapted to the environmental conditions in which they are found. The recommended procedures for using a zoo also apply to using an institutional aquarium. Because of the cost of maintaining an aquarium, there is usually an admission fee. As is true for planetariums, special rates are usually given to school groups.

### Libraries as a Community Resource

Although firsthand experiences in observing, demonstrating, and experimenting are of paramount importance in learning science concepts and learning the methods of science, we should not leave children with the misconception that these are the only ways of learning about science. Books and periodicals are the most commonly used sources for learning about science. This is as true for the scientist as it is for

the nonscientist. Scientists and science laboratories could not be maintained without good libraries.

It is, therefore, important that the practice of using the library be encouraged, rather than discouraged, while pupils study science in the elementary schools. As evidence of the scientist's point of view regarding the importance of using good science books, the American Association for the Advancement of Science and the National Science Foundation publish bibliographies of science books for children. These bibliographies can be obtained by writing to the American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C., 20005.

Librarians report that a very high proportion of the questions that children bring to them deal with science. To provide for this interest, most libraries maintain a good selection of children's books on science. These books can be used for several purposes. They make it possible for children who want to find out more about certain science topics to do so. They supply information on new developments in science. Some deal with selected science topics in greater depth than is possible in a science textbook. Others present interesting biographies of notable scientists.

One of the best ways of finding out how you can encourage your pupils to use library books in science is to visit the science section of the children's reading room in the library in your community. Acquaint yourself with the wide selection of titles. Take out several books and read them. Then tell your children about the books. If this is done periodically, you can be sure that more and more of the children will begin using the library.

## USING AUDIOVISUAL MATERIALS IN SCIENCE TEACHING

A great variety of audiovisual materials is being used in the teaching of science. They range from simple line diagrams drawn on the chalkboard by teachers to elaborate motion pictures that cost thousands of dollars to produce. All are designed to enhance teaching and learning through the use of the visual and/or auditory senses.

Audiovisual materials can be used to show objects, conditions, and events that are not immediately or directly available to pupils, thus extending the range of the pupils' classroom experiences. These may include such subjects as the research work of scientists in Antarctica, the earth as seen from a spacecraft, and conditions at the bottom of the ocean as photographed by a submarine camera.

Audiovisual materials can restructure the time and sequence of pupils' activities and experiences, thus making the activities and experiences more effective for educational purposes. Such materials include tape recordings of interviews, which become reliable records of questions asked by pupils and answers given by an authority on a topic being studied in science; pictures taken to produce reliable records of objects or processes observed during a field trip; pictures of the same child at different ages to show growth changes; slow-motion pictures of activities such as running, in which the sequence of body movements takes place so rapidly that it is difficult to observe the details; or time-lapse movies of events such as the opening of a flower bud, which takes place so slowly it is impossible to observe the details of the marvelous processes involved.

Audiovisual materials may be used to demonstrate procedures and to illustrate concepts in science. They can be used to show how to plan and conduct an experiment, to dissect an animal, to use a piece of apparatus, to prepare exhibits, to conduct a science fair, or to write a report. They can be used as an aid in explaining such concepts as the interdependence of living things, action-reaction, electric currents, work, chemical change, adaptations of living things, and practically any other concept studied in science. Audiovisual materials can be used to organize and

integrate concepts dealing with such topics as weather, nutrition, and spacecraft. They can be used as an aid in visualizing such concepts as the enormous solar system and the minute atom.

### Types of Audiovisual Materials

There are two general types of audiovisual materials: those that require special equipment in order to use them and those for which no special equipment is needed. The following audiovisual materials require special equipment, such as cameras, projectors, recorders, microscopes, and phonograph machines:

16 mm. motion picture films
8 mm. motion picture films
filmstrips
2" x 2" slides
prepared microscope slides
large transparencies for overhead projection
recordings, both tape and disk

Among those materials that do not require special equipment are exhibits and models. The remainder of this section will deal with ways in which all of these materials can be used in teaching science.

### Motion Pictures

The following list of selected titles, from the catalogue of one of the large producers of educational films, clearly indicates that science subjects are covered extensively by motion pictures and that films are available for every grade level:

FOR KINDERGARTEN AND GRADES 1–3

*Animals and Their Foods*
*Electricity for Beginners*
*Energy Does Work*
*How Air Helps Us*
*How Animals Help Us*
*How Simple Machines Make Work Easier*
*Living and Non-Living Things*
*Rocks: Where They Come From*
*Sound for Beginners*
*Winter Comes to the Forest*
*Zoo Babies*
*The Big Sun and Our Earth*
*What Do We See in the Sky?*

FOR GRADES 4–6

*Air All About Us*
*Chemical Changes*
*Color and Light*
*Energy and Its Forms*
*Fossils: Clues to Prehistoric Times*
*Heat and Its Behavior*
*How Weather Is Forecast*
*Introducing Atoms and Nuclear Energy*
*Magnetism*
*Beyond Our Solar System*
*Adaptations of Plants and Animals*
*Fish and Their Characteristics*
*How Flowers Make Seeds*

FOR GRADES 7–9

*Airplanes: Principles of Flight*
*Conserving Our Forests*
*Electricity: How It Is Generated*
*Field Trip to a Fish Hatchery*
*Fire and Oxidation*
*Electrons and Electronics: An Introduction*
*Force and Motion*
*Latitude, Longitude, and Time Zones*
*Weather: Understanding Storms*
*Gravity*
*The Structure of the Earth*
*Behavior in Animals and Plants*
*Cell Biology: Life Functions*

As is true in selecting any audiovisual material, films should be selected for use in science teaching only when they relate closely to the work at hand.

Furthermore, they should be suitable for the grade level at which they are to be used. Film catalogues carry descriptions of each listed film along with a statement regarding the grade level for which it is best suited. For example, here is a description of the one-reel, eleven-minute color film *Animals and Their Foods* given in the catalogue: "The animals in this film are divided into groups according to the foods they eat: (1) plant eaters; (2) meat eaters; and (3) those that eat both plants and meat. The illustrations explain the basic concept that different animals are suited to eating different kinds of food." Another example is the description for the film entitled *Electricity for Beginners:* "A flashlight that doesn't work leads Frank and Joan to a basic concept: Electricity flows only in a continuous pathway. Simple demonstrations in a hardware store show how electricity can produce heat, light, and magnetism, which in turn can produce motion in a small motor. The film also emphasizes the importance of safety with electricity."

Larger school systems usually maintain an audio-visual center for motion pictures such as those previously discussed. Where this is not the case, films have to be rented from an agency. Under such conditions, teachers often must plan for the use of specific films as much as a year in advance. But it is not always possible to anticipate the exact date upon which a specific topic will be used in a science class. Therefore, the dates for which films are ordered are usually tentative. But the films arrive on the dates ordered and can be kept for only a few days. It is not always possible to coordinate teaching with the prearranged film schedule. When this happens, teachers have to adapt their use of the film to fit the situation. When the film arrives ahead of the time that the topic for which it was selected is being studied, the teacher may find it necessary to use the film as a preview for what is to come in science. When it arrives after the topic has been studied, the teacher may find it advantageous to use the film as a review of the topic.

Much of the success experienced by teachers in using movie films is a direct result of the preparation they make for their use. They select only those films that are related to what they are teaching in science. They read carefully the teaching guide that accompanies the film to become better acquainted with its purpose and content. They preview the film to find out for themselves what it is all about. They prepare a suitable introduction to be used in presenting the film to their pupils. After the film is shown, it is discussed with pupils to make certain that its important points are reviewed and related to the work at hand.

Also available to teachers are 8 mm. cartridge-type film loops, known as single concept films. Such cartridge films require no threading, no rewinding, and only minimal handling. Each cartridge provides about three to five minutes of viewing time, pinpointing and highlighting a single concept. Thus, digestion, the structure of the atom, sound waves, and carbohydrates all might be subjects for the cartridge films. These films, although they do require special, moderately priced projection equipment, are an extremely valuable adjunct to the teaching of a lesson. They enable the teacher to point up a particular aspect of the lesson with ease and clarity.

### Filmstrips

There are filmstrips for practically every topic studied in science. Filmstrips have some advantages over movie films. Since they are less expensive, individual schools can have selected collections of them readily available for use in the classroom. It is easy to operate a filmstrip projector. Pupils can participate by asking questions and giving explanations during the time it is being shown. It can easily be reversed to review frames whenever desirable.

Some filmstrips are accompanied by sound records. The sound accompaniment is usually commentary for

each of the frames and must be synchronized with the pictures by the operator of the projector. The accompanying sound commentary covers all important points with which each frame deals. Printed commentaries are also supplied with filmstrips so that the teacher may read as the filmstrip is being shown. The use of a printed commentary gives the teacher the advantage of being able to pace the showing of the filmstrip to accommodate the reactions and questions of the viewers. It is desirable for teachers to preview the filmstrips before classroom use. Furthermore, only those filmstrips that relate closely to the topics being studied should be selected for use.

### 2" x 2" Slides

These are transparencies whose dimensions are 2 inches by 2 inches. Generally they are color transparencies. Most of the advantages of filmstrips also hold for 2" x 2" slides. Also, while the pictures in a filmstrip are arranged in a definite sequence, it is possible to arrange the 2" x 2" slides into whatever sequence seems appropriate at the time. The 2" x 2" slides have another advantage in that teachers and pupils can take their own pictures with the proper camera and use them to make up their own classroom collection of slides. Here is a list of subjects, each of which could be made into a picture story using 2" x 2" slides:

Seasons in Our Town
Machines Make Work Easier
The Care of Animal Pets
Evidence That Air Is a Substance
Increasing and Decreasing Friction
Evidences of the Water Cycle
Rates at Which Different Seeds Grow
Forces
Units of Measurement

### Using the Microscope

The compound microscope is the type most commonly used in classrooms. This microscope has an eyepiece lens and an objective lens, each one magnifying the image of the object to be viewed. Light strikes the mirror near the base of the microscope and then passes through an opening in the stage. The light continues through the objective lens, the tube, and the eyepiece until it reaches the observer's eye.

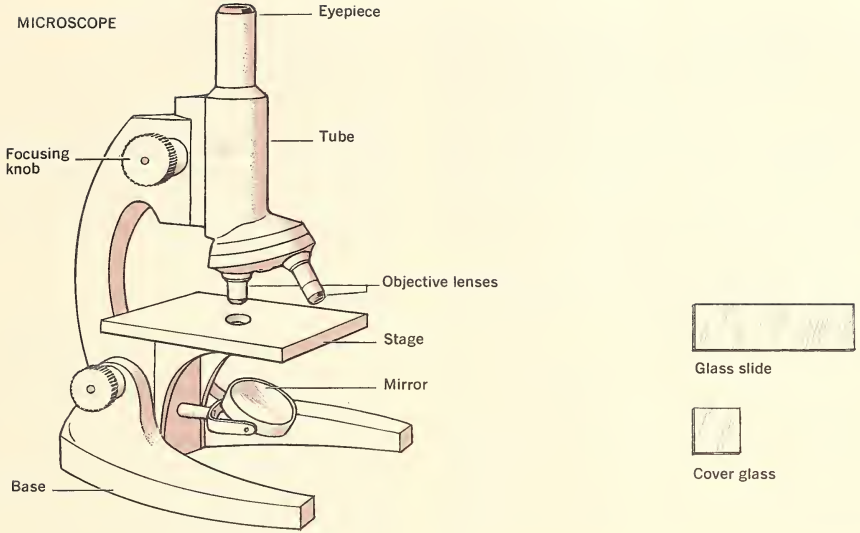
To magnify an object, it is necessary that only a *very thin* segment of the object be used. When magnifying onionskin, for example, use a razor blade to cut and peel off the thinnest possible layer. Place the layer on a glass slide and use a medicine dropper to add one drop of water to the layer. (Note: It is often possible to obtain a better image by using a drop of water-diluted iodine rather than plain water.) Next, place a cover glass over the glass slide.

When focusing, place the microscope near a light source such as an open window or a lamp. Adjust the stage so that, when looking through the eyepiece, you see a bright circle of light. Next, with your eye away from the eyepiece, slowly turn the focusing knob, lowering the objective lens until it *almost touches* the cover glass. Look again through the eyepiece and slowly turn the focusing knob to *raise* the objective lens. When properly focused, the cells of the onionskin should appear as rectangular, or bricklike, shapes.

### Prepared Microscope Slides

As early as the fourth grade, children should be introduced to the microscope. If possible, they should be shown how to prepare slides of living material such as yeast cells, cheek cells, microorganisms in pond water, and the cells of an elodea leaf.

There are limits to how far children can go in preparing their own slides of living material. At the




time that cells are being studied in science, it is desirable to have available a collection of prepared microscope slides of such subjects as paramecia, spirogyra, molds, bacteria, yeast, roots, stems, leaves, flower parts, human bone, human skin, human muscle, and human blood. These slides can be obtained from any biological supply house. Although they cost about $1.00 a slide, they are permanent slides, and with proper care they can be used for a long time.

A microprojector is an instrument that can be used to project the objects on microscope slides onto a sheet of paper. The projected image is enlarged, and it is thus possible for a number of children to see it at the same time. Even though a microprojector is used, children should also have an opportunity to view the slides through a microscope.

### Large Transparencies for Overhead Projectors

The overhead projector is operated from the teacher's desk in the front of the classroom. As the teacher operates the projector, he faces the class and the picture is projected on a screen in back of him. Pictures are prepared on a transparent material and may be either black and white or colored. Their size is about 5 inches by 7 inches. As each picture is to be shown, it is placed upon the stage of the projector, where it is visible to the teacher during the time it is projected on the screen. This makes it possible for the teacher to face the class as he talks and to point out any part of the picture to which he wishes to call particular attention. Transparencies may be obtained from scientific supply houses on a number of

topics related to science. A catalogue of one supply house has listed the following series of transparencies for use in elementary science: Human Body Series, Animal Series, Astronomy Series, Atom Series, Geology Series, Meteorology Series, Electricity Series. The Astronomy Series consists of the Solar System, the Sun, Seasons; the Year, Month, and Day; Time Zones; Solar and Lunar Eclipses; Telescopes; and Satellites. This is an overlay series, which means that there is a set of four transparencies for each topic such as the Solar System. As each transparency in the series of four is laid upon the preceding one, it adds information to the ideas that are to be developed by the set.

"Do-it-yourself" kits are available for those who would like to make their own transparencies. The kits can be used to make diagrams, charts, and graphs. They can be produced in black and white or color. The audiovisual departments in some schools have persons skilled in making transparencies produce transparencies for teachers or teach them how to make their own.

### Recordings

Both tape and disk recordings can be obtained on various subjects related to science. Some of the titles are listed below:

DISKS

*American Bird Songs (an album of 6 records)*
*Adventures in Sound and Space*
*Science of Sound*

TAPES

*Electricity Goes to Work*
*Galileo Tests a Theory*
*Van Leeuwenhoek and the Little Animals*
*How Men Behave*
*Scientists at Work*
*Digging Up the Past*
*The Ocean and Weather*
*The Rocket Man*
*Satellite Story*

The National Tape Recording Catalogue, published by the Department of Audiovisual Instruction of the National Education Society, lists more than one hundred titles dealing with topics in science. Many of them, such as the ones previously listed here, are appropriate for use in both elementary and junior high school science classes.

### Exhibits

One of the most common uses of exhibits in science teaching is the science fair. Where science fairs are noncompetitive and voluntary, they may have very positive educational value. They encourage children to conduct projects of various kinds in coordination with their work in the science classroom. Children are also encouraged to organize the pertinent ideas into forms that are clearly visible. Imagination, creativity, and resourcefulness are applied in preparing science exhibits. In displaying their exhibits, children gain recognition for their efforts. Furthermore, children learn science from the exhibits prepared by other children. At their level, a science fair may serve much the same purpose that scientific meetings serve for the scientist.

In another section of this Teacher's Guide, the use of museum exhibits in teaching science has been discussed. Some museums prepare small exhibits of different kinds that are loaned to schools. These are prepared in glass-covered boxes for display. Generally, a guide book is sent with the exhibits to help the teacher get the most out of them.

Science museums have become quite popular in some of the larger cities. In these museums the exhibits have been prepared to teach people about scientific discoveries and technological inventions. Before a teacher makes a decision to take his class to a science

museum, he should visit the museum to determine which of the exhibits, if any, are related to topics being studied in his science class. If there are none, he probably should not make the effort to take his pupils.

Industrial firms include exhibits of various kinds among their educational materials. Generally, the exhibits are very attractive but deal rather exclusively with products and/or services in which the industry is primarily interested. Teachers should avoid cluttering up their classrooms with any such exhibits that are not closely related to topics being studied. Exhibits that are given to the school, or those that are pupil-made, often introduce storage problems that teachers find difficult to solve.

Posters of various kinds might be classified as exhibits. They can be used for many different purposes in science. Posters can be made to represent graphically such concepts as the water cycle, the oxygen cycle, interdependence of living things, the law of the lever, the conservation of energy, classification systems, the composition of the earth, electric circuits, and many other scientific concepts.

### Models

There are many ways in which models can and should be used in teaching science. Often the use of a model is the only way in which the pupil can "get" the idea that the model represents. The globe of the earth, commonly found in classrooms, is a good example of such a model. It would be extremely difficult to think of the earth as a sphere without such a model. Models of the solar system serve a similar purpose. Models of the human skeleton, the brain, the heart, the eye, the ear, and other parts of the body can be used to help children obtain a better understanding of what the inside of the body is like. Models of atoms and molecules can be used to gain a better understanding of the building blocks of nature.

All the models mentioned above can be obtained from scientific supply houses. On the other hand, children can make many of them. If they do, they will probably come to understand the pertinent concepts better than when they use a commercially made model. In making a model of the solar system, children learn much more about comparative sizes and distances than when merely observing a manufactured one. Similarly, when they construct a model crystal, using toothpicks and wax balls, they come to understand the relative positions of atoms in crystals better than when they observe a prepared model. By using clay, pupils can make models of different kinds of cells, craters on the moon, fossils, the ocean floor, volcanoes, the brain, and molecules. Styrofoam balls of assorted sizes have been used in making models of planets and molecules. Cellophane bags can be used in making three-dimensional models of a typical cell. When given the opportunity, children delight in thinking up ways of making models of the different things they study in science. In the "thinking up" process, they are adding new dimensions to their understanding of the concepts.

## CREATING INSTRUCTIONAL MATERIALS

In preparing a science program such as *The Macmillan Science Series,* it is impossible to anticipate every kind of learning situation that will confront the teacher in his day-to-day work. Schools vary from one community to the next. Classes within the school vary, as do the children within a particular class. For these reasons, teachers will find it advantageous from time to time to develop supplementary instructional materials adapted to the unique situations that they encounter in their teaching.

Because of the many ways in which learners may come to understand scientific concepts, the teaching of science provides unusual opportunities for teachers to create dynamic instructional materials. The re-

mainder of this section will include suggestions on how a teacher might begin.

Throughout *The Macmillan Science Series,* demonstrations are written into the text to introduce problems or to reinforce concepts. Additional material is suggested in the TAE. There are other ways, too, beyond those suggested in the TAE whereby concepts and their application can be demonstrated. Here are some questions to think about:

1. What are some ways, other than those given in the text, that can be used to demonstrate that air occupies space?

2. How many ways can you show that vibrating objects produce sound?

3. How many examples can you find of the fact that living things are interdependent?

4. In what situations have you witnessed the concept that once a body is set into motion it continues in a straight-line motion of unchanging velocity until acted upon by an unbalanced outside force?

5. In what other ways can you demonstrate diffusion as an example of the movement of molecules of one substance throughout another?

Questions such as these can be asked about every science concept that is demonstrated in your science text. They can serve as guides to "thinking up" or creating additional demonstrations. The more demonstrations or examples of a concept that can be shown to pupils, the better will be their understanding of it.

Creativity can really bloom when applied to the designing of experiments. Detailed descriptions are given for many experiments in the series. This is done to help pupils learn how the various factors in an experiment are handled. It may be that, for some pupils, more experiments of this type should be given, and it is here that the teacher could profitably spend some time in developing additional ones. In some instances it might be advantageous to modify one of the experiments in the text to include different materials and different experimental situations. For example, in an experiment where bread is used to determine the best conditions for mold growth, a variety of organic materials might be used in addition to bread. After observing the results of one such experiment, pupils frequently give the clue to new experiments by asking the question, "I wonder what would happen if this or that were done?"

The golden opportunity for developing new experiments often comes from something that happens during a science lesson. It may come from a searching question asked by one of the pupils. It may come from an unaccountable observation made by someone in the class. It may come when an experiment does not turn out as the class expected because the hypothesis being tested is not a tenable one. The following are examples of how this has happened in different classes.

In one class the teacher was performing a demonstration to show that soil contains air. As the teacher poured water into a large container of soil, bubbles formed at the surface of the soil. The teacher then asked the question, "What do the bubbles indicate?" As expected, one of the pupils replied. "It shows that there is air in the soil." The teacher followed with the question, "What did you observe that supported such a statement?" The pupil responded, "You could see bubbles which proved that air was coming out of the soil." The teacher then asked the class if they agreed. All but one boy did. He asked, "How do you know that the bubbles were formed by air rather than some other gas?" No one could answer the question, and the class now had a problem. How could you prove that the gas coming from the soil when you poured water into it was air? The teacher, working with a small group of pupils, devised a method for capturing the gas that was given

off when water was poured into the soil. They also devised ways of testing the gas to determine if, in fact, it was air.

In a third grade class the pupils had conducted an experiment to determine how temperature affects the growth of mold on bread. They had kept the moistened pieces of bread in small aluminum pans. As they had expected, considerable mold had developed on the bread that had been kept in a warm place. Little or no mold had developed on the pieces of bread that had been kept in the refrigerator. During the time each pupil was examining the bread mold in the pans, one of the pupils held the pan over his head. As he looked up at the bottom of the pan, he saw several tiny holes in it. He asked the teacher what caused them. The teacher commended him for discovering the holes and then asked the class how they could find out what caused the holes in the pan. This led to a series of very interesting activities, including experimentation and the use of several knowledgeable resource persons. Although the teacher and the children were not able to solve the problem through their own experiments, they learned a great deal about the limitations of their own knowledge and abilities and how to use resource people in solving complex problems. Investigation of the problem showed that carbon dioxide from the mold combined with salt from the bread to form sodium carbonate, which caused the holes to form in the aluminum.

In a fifth grade class the pupils had had a number of experiences in heating objects such as iron wire. They had found that heating the objects caused them to expand. The teacher had encouraged the pupils to give other examples from their own experience. Some mentioned that they had seen pictures of steel rails that had expanded on hot summer days and forced the railroad tracks out of shape. Others told of seeing the same thing happen on concrete highways. One girl in the class said she now knew why the drawers in her dresser became stuck in the summer. She explained that the heat expanded the wood so that the drawers became too tight to move in and out easily. Her explanation seemed reasonable to all members of the class. The teacher asked the class, however, if they were sure that wood expanded when heated. This was a good question, since they had done no experiments with wood. The class accepted the challenge to plan an experiment to test the hypothesis that "wood expands when heated."

In planning a method for testing the hypothesis, the children made many suggestions. With the help of the teacher, each suggestion was examined. Finally this plan was accepted: Three holes were bored into a piece of pine board. Then a length of wooden dowel was cut into three equal pieces. It was found convenient to use a one-inch pine board, to make the holes $\frac{3}{8}$ inch in diameter, to get $\frac{3}{8}$-inch dowels, and to make each piece four inches long. Each piece of dowel was numbered, and its hole was given the same number.

The first dowel was then put into an oven and heated at 200° F. for an hour. The second dowel was put into the freezing compartment of a refrigerator for an hour. The third dowel, the control, was left in the room.

At the end of the hour, each dowel was again fitted into its hole in the board. The heated dowel did not expand or stick as was expected, but fit more loosely than it had before it was heated. The cold dowel fit more tightly than before. The dowel that had been left in the room fit in the same way as it had before. The children were amazed. Some of them said, "Our experiment didn't work!" The teacher reassured them that the experiment had worked; it just didn't turn out as they had expected. Now the children really had a problem: If heat doesn't cause dresser drawers to stick in the summer, what does?

The teacher followed up by encouraging them to think of other possible reasons. After a while someone

suggested that it might be that high relative humidity on certain days in the summer caused the drawers to stick. How could this hypothesis be tested? Finally someone hit upon the idea of suspending one of the dowels in a covered jar that had water in the bottom of it. It was explained that the air above the water would soon become filled with water vapor, and the relative humidity would be very high. This seemed reasonable to the class, and so they hung one of the dowels above the water in the covered jar. They left it hanging this way until the next day. When they removed the dowel, they found that it had swollen so that they couldn't even force it into its hole.

As you can see, this experiment took several days to complete. Was it worth the time? This question can only be answered "Yes" if you believe that the creative thinking involved in planning an experiment such as this is important in the education of children.

### Picture Stories and Other Supplementary Materials

The picture stories beginning with Book 3 have been used to reinforce concepts developed in the texts by showing how these concepts apply in human activities. There are many possibilities for applying the picture story technique to other concepts in local situations. For example, in Grade 1, where the concept of seasonal changes is introduced, a teacher might prepare a collection of snapshots of the class taken during the different seasons of the year. These could then be arranged in a picture story album or bulletin board display. Such a picture story would incorporate the local climatic conditions in ways that are not possible in a single standardized version of the concept of seasonal changes.

The possibilities for picture stories are practically unlimited. Whenever they are prepared, they should deal clearly with an application of one or more science concepts.

Teachers might also find it worthwhile to prepare supplementary materials for introducing certain units in the text. Bulletin board or large poster displays can be prepared, following the format used in the text. If this is done, the displays can be used to facilitate pupil discussion; they should be designed to help pupils understand better what the unit is about and to make more clear the purposes for studying it.

There may be local situations that relate in unique ways to certain of the units. Where this is so, supplementary materials can be prepared to show the relationship. For example, in communities near the ocean, the unit on oceanography (Book 5) would be introduced quite differently than it would be in communities far removed from the ocean. Because of the climatic differences among communities, units having to do with weather might be introduced in different ways. The unit on conservation (Book 6) would be introduced differently in urban communities than in rural communities. Thus, before undertaking any unit in science, the teacher should investigate possible ways of introducing it so that it relates most closely to the unique experiences of the pupils. When this is done, it will often lead to the development of unit introductory materials to supplement those in the text.

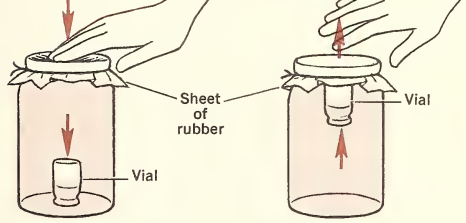
### Reviews

One of the many strengths of *Science for Tomorrow's World* is the way in which units are reviewed. Review sections occur frequently and in a variety of interesting forms throughout each book. There are several phases involved in a review of concepts. One phase has to do with *recall* of the facts related to the concepts developed. A second has to do with *relating* the facts to the pertinent concepts. A third has to do with *applying the concept* or using it to explain something. A fourth has to do with using the concept to *predict* what will happen under certain conditions to which the concept applies. In other words, good re-

views provide for practice in identification, interpretation, application, and prediction. Since there are numerous commonly used ways of providing practice with each of these, the creating of new ways is an exciting challenge to any teacher.

Good reviews include the skills and attitudes involved in scientific inquiry. There are several ways of reviewing the skills involved in the planning of an experiment. One way is to present a problem which can be answered by experimentation and to then ask the pupils to plan the experiment. They might do this individually and then write up their plans. They might work in groups of four or five, and each group could then present its plan to the entire class. Or the entire class, with one of the pupils as the leader, might work up the plan. In the latter two instances, all pupils have the opportunity to take part in the evaluation of the planning. Reviews of this sort will be more effective if the teacher gives the students a novel problem—one that is not like any they have worked on before. Another way to provide for review of skills involved in experimentation is to keep a close record of an experiment, noting all pertinent details, including the results and the conclusions. Some of the common errors in experimentation should then be introduced into the record. Give the pupils the experiment as it is written, and ask each of them to evaluate it.

There are many ways in which skill in observation can be practiced through reviews. Demonstrations might be performed and pupils asked to record their observations. Where this is done, the demonstration must call for rather careful observation. One such activity might be the cartesian diver. One cartesian diver demonstration calls for a flat bottle filled with water and covered with rubber sheeting (see diagram). Suspended in the water is an inverted vial that is nearly filled with water. As the rubber sheeting is pressed, the vial goes down. As the pressure is released, the vial rises. The class is asked to tell why the vial went down and then up. The system under observation consists of bottle, water, vial, and hands. Those who have never seen the demonstration before must observe quite carefully to be able to tell that the vial goes down when the hands are pressing the rubber sheeting and that it comes up when the pressure is removed. There are many other demonstrations like this one that teachers could develop and use to give practice in observing.




Here is another example, which has to do with two scientific attitudes—objectivity in evaluating evidence, and reluctance to make a judgment until conclusive evidence has been accumulated. An investigation can be described in which data of both sound and dubious quality are reported. Based upon the evidence, certain conclusions are drawn. Some of the conclusions are consistent with the data, and some go beyond the data. After pupils have read the investigation, they are asked to evaluate the conclusions. What they react to in their evaluations should indicate whether they are weighing evidence and suspending judgment.

In this section we have seen that there are good reasons for teachers to create instructional materials. Through the process, teachers are providing for one of their basic needs, the need to be creative. Consequently, they gain greater satisfaction from their teaching. But more important are the values that come to the pupils who use the materials that the teachers prepare. The learning idiosyncrasies of pupils will be more nearly met, and their relative achievement in learning the concepts and using the methods of scientific inquiry will be improved.

## OVERVIEWS OF UNITS IN BOOK 1

This section provides a brief overview of each unit in the book. At the end of the section you will find a listing of the table of contents of each book. This overall table of contents will give you an opportunity to visualize the total program of *Science for Tomorrow's World* and to see the interrelationships of subject matter in the conceptual organization of the series.

### Unit One: The Weather Changes

The subject matter for this unit, the child's first formal experience with science instruction, was selected because weather is a set of phenomena familiar to children. It enables the teacher to build scientific concepts on a foundation of previous experiences.

The unit begins with a general discussion that makes use of the children's past experiences with weather changes. The children are shown the part weather plays in determining their activities and those of other living things.

The children are presented with properties of air related to weather: air is all around us; evaporation and condensation are two physical changes caused by air; air has weight; air contains water; air moves and pushes (wind); and water vapor in the air may become crystallized and turn into snow.

### Unit Two: Keeping Well

This unit enables the child to become conscious of the responsibilities he has to himself. As children mature, they gain an awareness of their own role in keeping themselves well. The learnings in this unit present scientific explanations for actions they have been arbitrarily trained to do.

The unit opens with the child's discovery of himself as a complex organism which needs constant maintenance. Children already have an idea of which foods are healthy for them, but they do not know why. Simple nutritional concepts are presented. The children are then given actual experiences in food preparation.

The unit then turns to the scientific explanation of illness. The children are shown what germs (previously an abstraction) look like. A brief explanation of the germ theory enables the children to appreciate the necessity of innoculation and immunization to prevent the spread of germs. Fears about injections may be dissipated by giving the children an opportunity to discover how a hypodermic needle works.

The unit concludes with the importance of keeping clean as a check on the spread of germs.

### Unit Three: Pushes and Pulls

The children are introduced to the concept that man can use machines to help him do work. By using machines, man can more efficiently use his own energy.

Children are familiar with many machines. They see them all around—in the home, on the street, in the school. Various concepts are introduced to make the children aware of how machines help them and how machines work. They learn which machines help them pull or push things. Particular emphasis is placed on simple machines, such as the lever and the wheel. Many examples of how they make work easier are given.

With this brief background of how man can put things to work for him, the children are introduced to the concept of magnetism. Most children are familiar with magnets and what they do. In this unit the concept of a magnet as a "machine" to help man is presented. The children are first guided in discovering the properties of magnets (magnets can pull through glass, water, and wood; they are stronger at the ends than in the middle; some magnets are stronger than others; etc.). The children are then shown one of the ways that man puts magnets to work for him: a compass. The children are given the opportunity to engage in many activities, including making their own magnet and their own compass.

### Unit Four: Growing Up

This unit begins by having the children discuss a familiar experience—looking through the family album. Most children have seen pictures of themselves as babies. They are usually amazed that *they* could ever have been so small. Most babies look very similar to each other. As they start to grow, noticeable differences appear. When the children look around the room, they see that their classmates all look different. After a brief discussion of individual differences among children, the concept of living and nonliving things is introduced.

The unit turns from these general concepts to more specific scientific explanations of growth. First, bone structure and function are presented. Then tooth development and the importance of caring for teeth are stressed. All explanations are linked to common experiences that the children share.

The last section of the unit deals with mental growth. The children are encouraged to take the roles of other people, as well as themselves, in familar situations. The teacher has an opportunity to encourage insight into problems that all children face. Through the activities, children are led to an understanding that they grow up mentally as well as physically.

### Unit Five: Seeing and Hearing

This unit stresses the importance of two of our senses. The children are led to the understanding that through the use of their eyes and ears they can learn much about their environment.

Once the essential roles of these two senses have been established, the unit turns to some basic scientific concepts that relate to light and sound. The necessity of light for sight is discussed. The children then learn how to refract light into its component colors through the use of a prism or a mirror in water. They also learn that colored cellophane or glass actually absorbs, rather than adds, color. This concept is made very real by the discussion of the color of traffic lights. This section on sight ends by stressing how the children can care for their eyes.

An introduction to the scientific principles of sound follows. The children learn about vibrations and the carrying of sound waves. They learn that a doctor uses an instrument to enable him to hear faint sounds. They investigate themselves with home-made stethoscopes. The unit concludes by pointing out to the children the importance of testing their hearing and seeing a doctor if they do not hear well.

The frame of reference for this unit is a familiar setting—a pet store. From this starting place, the children are led to discover the basic tenets of classification and what things are necessary for the perpetuation of the species.

The second section of the unit provides a detailed study of one organism—the bird. A careful study of one type of animal will stimulate interest in learning more about other animals. Birds were selected because of the wide variety within the species and their accessibility for study.

The third section of the unit deals with the concept of protective coloring or camouflage. This concept is reinforced through the presentation of many concrete examples.

Finally, another type of animal, the ant, is suggested for further investigation by the children, either in or out of the classroom.

## SCIENCE FOR TOMORROW'S WORLD: BOOKS 1-6

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**TESTS FOR SCIENCE FOR TOMORROW'S WORLD**

On the following pages you will find tests for each unit in the book. The Macmillan Company authorizes any teacher using *Science for Tomorrow's World,* Books 1–6, to reproduce *for use in his or her classroom only* the tests in this guide.

# Unit 1: The Weather Changes

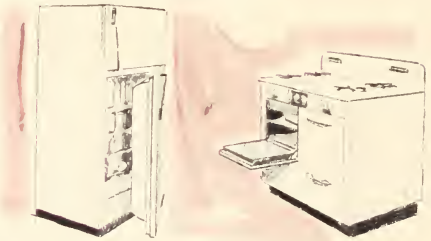
*Directions: Look at these pictures. Draw a circle around the picture that answers each question.*

1. It is raining. What should you wear?

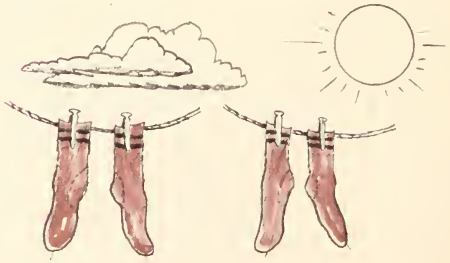
2. Can you tell which will make the snowman go away faster?

3. Which shows that the air is moving?

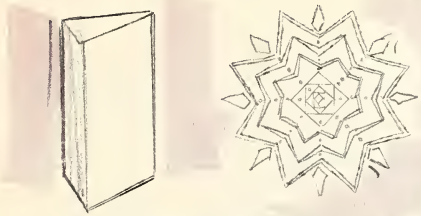
4. Where is the air warmer?



5. Which dries faster?



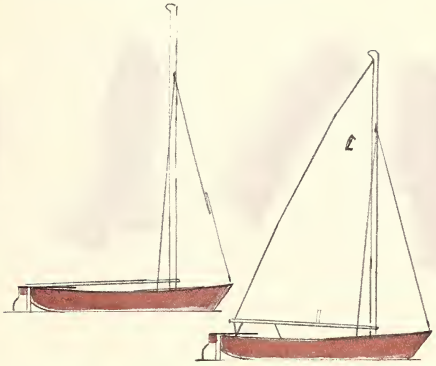
6. Which of these is a snowflake crystal?



7. Which shows that the wind is moving?

8. Which will make the puddle go away faster?

9. Which will the wind push faster?



10. This is a kite.

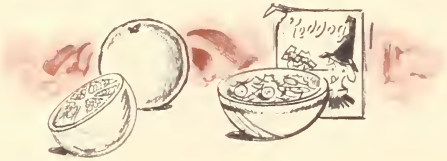
What makes it stay up in the air?

# Unit 2: Keeping Well

*Directions: Look at these pictures.*
*Draw a circle around the picture that answers each question.*

1. Which is a better breakfast?

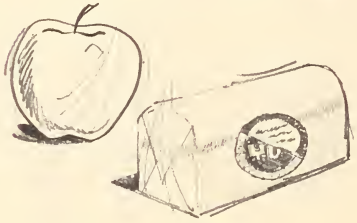
2. Can you choose the food that helps you play?



3. Which boy ate all of his breakfast?

4. Which girl gives her germs to other children?

5. Which food must mother wash to kill the germs?

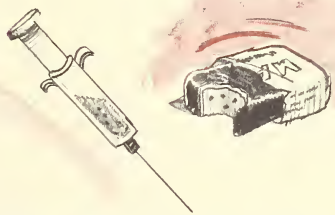


6. Where should you take your dog when he is sick?

7. Which dog will be clean?

8. Which are germs?

9. Which do you need before you can begin school?

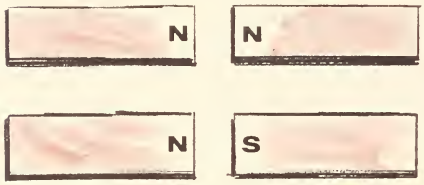


10. Which should you do when you are sick?

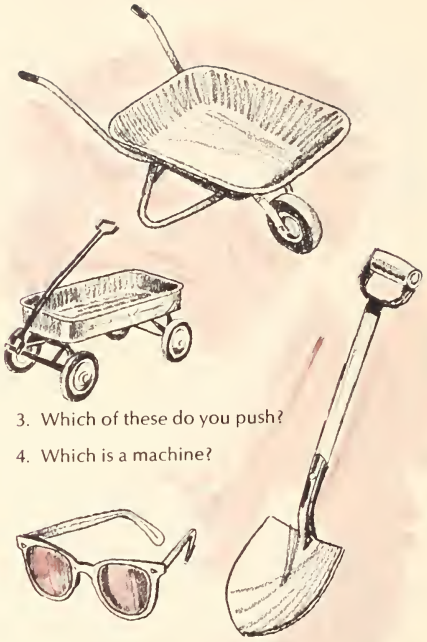
# Unit 3: Pushes and Pulls

*Directions: Look at these pictures. Draw a circle around the picture that answers each question.*

1. Which magnets push each other?



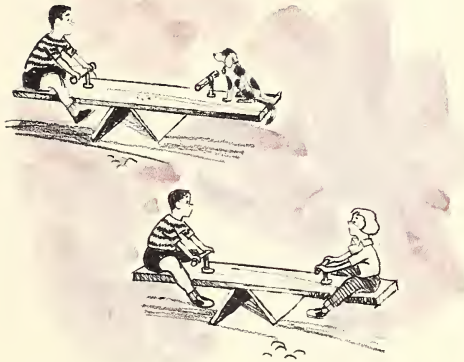

2. What things will a magnet pull?



3. Which of these do you push?
4. Which is a machine?

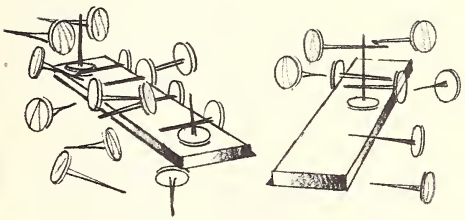
5. Which compass points north?

6. Which picture is right?

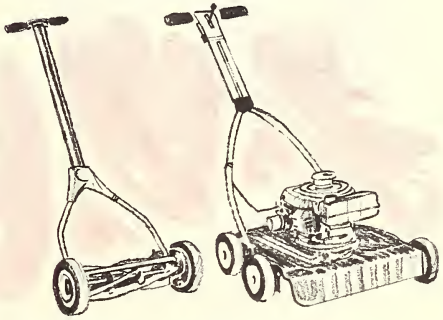


7. Which machine helps mother work faster?

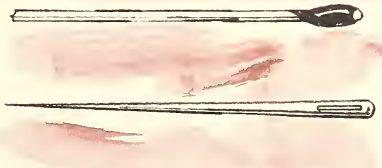
8. Which magnet is stronger?



9. Which machine helps father work faster?



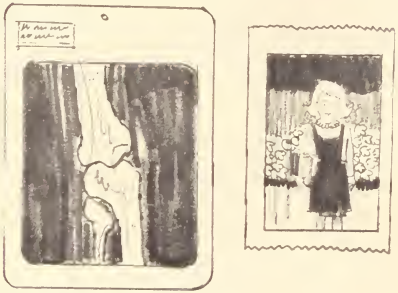
10. Which can you make a magnet?



# Unit 4: Growing Up

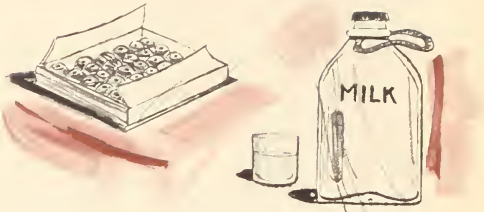
*Directions: Look at these pictures. Draw a circle around the picture that answers each question.*

1. Which kind of picture does an X ray show?

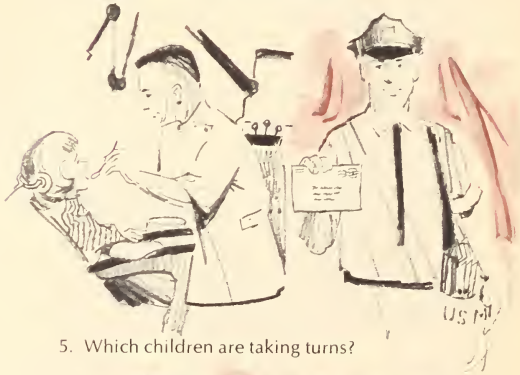


2. What thing grows?

3. What makes teeth strong?




4. Who helps you take care of your teeth?

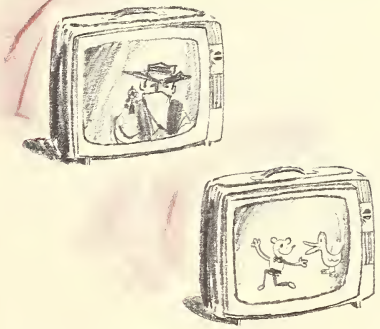


5. Which children are taking turns?

6. When will Tom's heart beat faster?

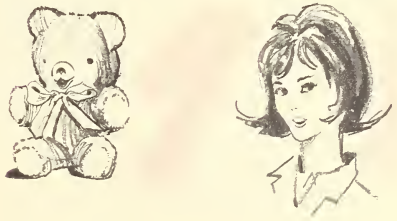
7. Which is a way to exercise?

8. Which television program should Tom see before he goes to sleep?



9. Which thing grows?

10. Which one should you tell when you are afraid?



# Unit 5: Seeing and Hearing

*Directions: Look at these pictures.*
*Draw a circle around the picture that answers each question.*

1. Circle the things you can see but can not hear.

2. Circle the things that give light.

3. Circle the bow that is made up of white light.

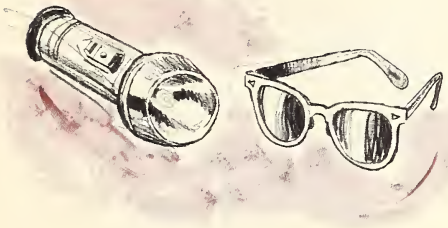
4. Circle the color of this traffic light.

Red Green

5. Circle the color of this traffic light.

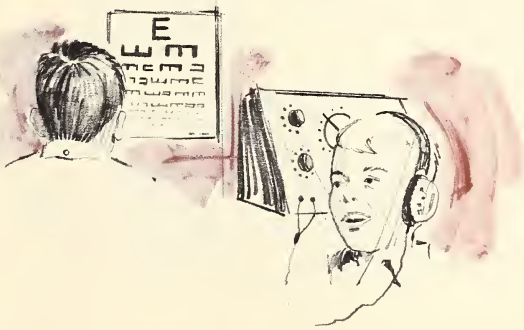
Red Green

6. Alice does not see well. Which will help her see better in the day? Circle it.



7. Circle the sound that will be louder.

8. Circle the child who is testing his hearing.



9. Could you hear both drums? Circle the answer.

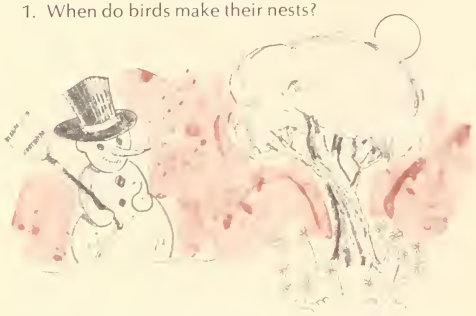
Yes No

10. Bob does not hear well. Circle the seat where he should sit.

# Unit 6: Animals

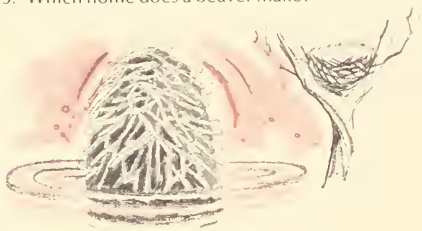
*Directions: Look at these pictures. Draw a circle around the picture that answers each question.*

1. When do birds make their nests?



2. Which do baby birds eat?

3. Which home does a beaver make?



4. Which animal lives in the water?

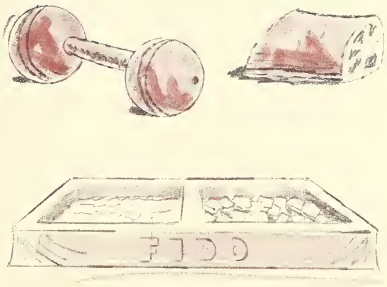
5. Which animal can fly?

6. Which animal keeps babies warm in a nest?

7. Which animal has feathers?

8. Which is the mother bird?

9. Which do your pets need to live?




10. Where is it hard to see a green bird?

# Directory of Publishers of Science Books

Abelard-Schuman, Ltd., 6 West 57th St., New York, N.Y., 10019
Abingdon Press, 201 Eighth Ave., South, Nashville, Tenn., 37202
Affiliated Publishers, 1 West 39th St., New York, N.Y., 10018
Allyn and Bacon, Inc., 105 Tremont St., Boston, Mass., 02111
Americana Corporation, 575 Lexington Ave., New York, N.Y., 10022
American Association for the Advancement of Science, 1515 Mass. Ave., N.W., Washington, D.C., 20005
American Forestry Association, 919 Seventeenth St., N.W., Washington, D.C., 20006
American Library Association, 50 East Huron St., Chicago, Ill., 60611
American Museum of Natural History, Central Park West at 79th St., New York, N.Y., 10024
American Nature Association, 1214 Sixteenth St., N.W., Washington 20006
Appleton-Century-Crofts, Inc., 34 West 33rd St., New York, N.Y., 10001
Atheneum Publishers, 162 East 38th St., New York, N.Y., 10016
Basic Books, Inc., 59 Fourth Ave., New York, N.Y., 10003
Benefic Press, 1900 North Narragansett, Chicago, Ill., 60639
Bobbs-Merrill Co., 4300 West 62nd St., Indianapolis, Ind., 46206
R. R. Bowker Co., 62 West 45th St., New York, N.Y., 10036
Cambridge University Press, 32 East 57th St., New York, N.Y., 10022
Childrens Press, Inc., 310 South Racine Ave., Chicago, Ill., 60610
F. E. Compton & Co., 1000 North Dearborn St., Chicago, Ill., 60610
Cornell University Press, 124 Roberts Place, Ithaca, N.Y.
Coward-McCann, Inc., 200 Madison Ave., New York, N.Y., 10016
Creative Educational Society, Inc., 530 North Front St., Mankato, Minn., 56001
Criterion Books, Inc., 6 West 57th St., New York, N.Y., 10019
Thomas Y. Crowell Co., 201 Park Ave. South, New York, N.Y., 10003
Crowell-Collier and Macmillan, Inc., 640 Fifth Ave., New York, N.Y., 10019
Crown Publishers, Inc., 419 Park Ave. South, New York, N.Y., 10016
John Day Co., 200 Madison Ave., New York, N.Y., 10016
Devin-Adair Co., 23 East 26th St., New York, N.Y., 10010
Dial Press, Inc., 461 Park Ave. South, New York, N.Y., 10016
Dodd, Mead & Co., 432 Park Ave. South, New York, N.Y., 10016
Doubleday & Co., Inc., 575 Madison Ave., New York, N.Y., 10022
E. P. Dutton & Co., 201 Park Ave. South, New York, N.Y., 10003
Encyclopaedia Britannica Press, 425 North Michigan Ave., Chicago, Ill., 60611
Field Enterprises Educational Corp., Merchandise Mart Plaza, Chicago, Ill., 60654
Follett Publishing Co., 1010 West Washington Blvd., Chicago, Ill., 60607
W. H. Freeman and Co., 660 Market St., San Francisco, Calif.
Garrard Press, 510–522 North Hickory St., Champaign, Ill., 61820
Ginn & Co., 72 Fifth Ave., New York, N.Y., 10011
Golden Press, Inc., 850 3rd Ave., New York, N.Y., 10020
Grolier Inc., 575 Lexington Ave., New York, N.Y., 10022

Grosset & Dunlap, Inc., 1107 Broadway, New York, N.Y., 10010 (Mail orders to 227 East Center St., Kingsport, Tenn., 37660)

C. S. Hammond & Co., 515 Valley St., Maplewood, N.J., 07040

Harcourt, Brace and World, Inc., 750 Third Ave., New York, N.Y., 10017

Harper & Row, Publishers, 49 East 33rd St., New York, N.Y., 10017

Hart Publishing Co., 74 Fifth Ave., New York, N.Y., 10011

Harvey House, Inc., Irvington-on-Hudson, N.Y., 10533

Hastings House, Publishers, Inc., 151 East 50th St., New York, N.Y., 10022

Hawthorn Books, Inc., 70 Fifth Ave., New York, N.Y., 10011

D. C. Heath and Company, 285 Columbus Ave., Boston, Mass.

Holiday House, 8 West 13th St., New York, N.Y., 10011

Holt, Rinehart and Winston, Inc., Publishers, 383 Madison Ave., New York, N.Y., 10017

Horn Book, Inc., 585 Boylston St., Boston, Mass., 02116

Houghton Mifflin Co., 2 Park St., Boston, Mass., 02107

Indiana University Press, Bloomington, Ind.

International Publishers, 381 Park Ave. South, New York, N.Y., 10017

Virginia Kirkus Service, 317 West 4th St., New York, N.Y., 10014

Alfred A. Knopf, Inc., 501 Madison Ave., New York, N.Y., 10022

Lane Book Company, Menlo Park, Calif., 94025 (Distributed by Lippincott in all states east of Idaho, Utah, and Arizona)

Lantern Press, Inc., 257 Park Ave. South, New York, N.Y., 10010

Library Publishers, Inc., 153 North Michigan Ave., Chicago, Ill., 60601

J. B. Lippincott Co., East Washington Sq., Philadelphia, Pa., 19105

Little, Brown and Co., 34 Beacon St., Boston, Mass., 02106

Lothrop, Lee & Shepard Co., Inc., 419 Park Ave. South, New York, N.Y., 10016

McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N.Y., 10036

David McKay Co., Inc., 119 West 40th St., New York, N.Y., 10018

The Macmillan Co., 60 Fifth Ave., New York, N.Y., 10011

Macrae Smith Co., 225 South 15th St., Philadelphia, Pa., 19102

Medical Books for Children Publishing Co., 940 Upper Midwest Building, Minneapolis, Minn., 55401

G. & C. Merriam Co., 47 Federal St., Springfield, Mass., 01102

Julian Messner, Inc., 8 West 40th St., New York, N.Y., 10018

William Morrow and Co., Inc., 425 Park Ave. South, New York, N.Y., 10016

C. V. Mosby Company, 3207 Washington Blvd., St. Louis, Mo.

National Geographic Society, Department FBJ, 1146 16th St., N.W., Washington, D.C., 20036

National Science Teachers Association, 1201 16th St., N.W., Washington, D.C., 20006

Thomas Nelson & Sons, 18 East 41st St., New York, N.Y., 10017

The New American Library of World Literature, Inc., 501 Madison Ave., New York, N.Y., 10022

New York Graphic Society, 95 East Putnam Ave., Greenwich, Conn., 06830

Oxford University Press, 417 Fifth Ave., New York, N.Y., 10016

Pantheon Books, Inc., 22 East 51st St., New York, N.Y., 10022

Frederick A. Praeger, Inc., 111 Fourth Ave., New York, N.Y., 10003

Prentice-Hall, Inc., Route 9W, Englewood Cliffs, N.J., 07631

G. P. Putnam's Sons, 200 Madison Ave., New York, N.Y., 10016

Rand McNally & Co., Box 7600, Chicago, Ill., 60680

Random House, Inc., 457 Madison Ave., New York, N.Y., 10022
John F. Rider Publisher, Inc., 116 West 14th St., New York, N.Y., 10011
Ronald Press Co., 15 East 26th St., New York, N.Y., 10010
Roy Publishers, 30 East 74th St., New York, N.Y., 10021
St. Martin's Press, 175 Fifth Ave., New York, N.Y., 10010
Scholastic Magazines, 902 Sylvan Ave., Englewood Cliffs, N.J., 17631
Science Service, Inc., 1719 N St., N.W., Washington, D.C., 20006
William R. Scott, Inc., 8 West 13th St., New York, N.Y., 10011
Scott, Foresman and Co., 433 E. Erie St., Chicago, Ill.
Charles Scribner's Sons, 597 Fifth Ave., New York, N.Y., 10017
Shorewood Publishing Co., Inc., 304 East 45th St., New York, N.Y., 10017
Silver Burdett Co., Columbia Rd. and Park Ave., Morristown, N.J., 07960
Simon and Schuster, Inc., 630 Fifth Ave., New York, N.Y., 10020
L. W. Singer Co., Inc., 249–259 West Erie Blvd., Syracuse, N.Y., 13202
Spencer Press, Inc., 179 North Michigan Ave., Chicago, Ill., 60601
Sterling Publishing Co., Inc., 419 Fourth Ave., New York, N.Y., 10016
University of Chicago Press, 5750 Ellis Ave., Chicago, Ill., 60637
University of Michigan Press, 615 East University, Ann Arbor, Mich., 48103
University of Minnesota Press, 2307 University Ave., S.E., Minneapolis, Minn., 55414
D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J., 08540
Viking Press, 625 Madison Ave., New York, N.Y., 10022
Franklin Watts, Inc., 575 Lexington Ave., New York, N.Y., 10022
Albert Whitman & Co., 560 West Lake St., Chicago, Ill., 60606
H. W. Wilson Co., 950 University Ave., New York, N.Y., 10052
World Publishing Co., 119 West 57th St., New York, N.Y., 10019

## Directory of Film and Filmstrip Sources

### 1. GUIDES

*Audio-Visual Communication Review,* published bimonthly by the Department of Audio-Visual Instruction, Washington, D.C.

*Blue Book of Audio-Visual Materials* (annual), Educational Screen, Inc., 64 E. Lake St., Chicago, Ill.

*A Directory of 16mm Film Libraries,* U.S. Department of Health, Education and Welfare; U.S. Government Printing Office, Washington, D.C.

*Education Film Guide* (annual), The H. W. Wilson Co., 950 University Ave., New York, N.Y.

*Educators Guide to Free Films* (annual), Educators Progress Service, Randolph, Wisc.

*Filmstrip Guide* (annual), The H. W. Wilson Co., 950 University Ave., New York, N.Y.

*Modern Index and Guide to Free Educational Films from Industry* (annual), Modern Talking Picture Service, Inc., 3 E. 54th St., New York, N.Y.

*U.S. Government Films for Public Educational Use,* 1955, Office of Education, U.S. Department of Health, Education and Welfare; U.S. Government Printing Office, Washington, D.C.

*U.S. Government Films for Schools and Colleges* (annual), United World Films Inc., 1445 Park Ave., New York, N.Y.

## 2. DISTRIBUTORS OF AUDIO-VISUAL AIDS

American Cancer Society, Inc., 521 W. 57th St., New York, N.Y.

American Heart Association, Inc., Film Library, 44 E. 23rd St., New York, N.Y. (Films also available from local heart associations.)

American Museum of Natural History, Slide Library, Central Park West at 79th St., New York, N.Y.

American Red Cross (Contact nearest American Red Cross chapter.)

Association Films, Inc., 347 Madison Ave., New York, N.Y. (Branch offices in Ridgefield, N.J.; Dallas, Tex.; San Francisco, Calif.; La Grange, Ill.)

Bell Telephone System (Contact local Bell Telephone Co. offices for address of regional distributor; or contact the American Telephone and Telegraph Co., Motion Picture Section, 195 Broadway, New York, N.Y.)

Blackhawk Films, 1235 W. 5th St., Davenport, Ia.

Better Vision Institute, Inc., 230 Park Ave., New York, N.Y.

University of California, University Extension, Educational Film Sales Dept., Los Angeles, Calif.

University of Southern California, Audio-Visual Services, Dept. of Cinema; University Park, Los Angeles, Calif.

National Film Board of Canada, 680 Fifth Ave., Suite 819, New York, N.Y.

Carousel Films, Inc., 1501 Broadway, New York, N.Y.

Churchill-Wexler Film Productions, 801 N. Seward St., Los Angeles, Calif.

Coronet Instructional Films, 65 E. South Water St., Chicago, Ill.

DeKalb Agricultural Assn., Inc., Educational Dept., 310 N. 5th St., DeKalb, Ill.

Walt Disney Productions, Educational Film Div., 500 S. Buena Vista Ave., Burbank, Calif. (Branch office in New York, N.Y.)

E. I. duPont de Nemours & Co., Inc., Motion Picture Distribution, Advertising Dept., Wilmington, Del.

Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill. (Branch offices in Hollywood, Calif.; Atlanta, Ga.; Skokie, Ill.; New York, N.Y.; Dallas, Tex.; Toronto, Ontario, Canada.)

Educational Testing Service, 20 Nassau St., Princeton, N.J. (Branch office in Los Angeles, Calif.)

Film Associates of California, 11014 Santa Monica Blvd., Los Angeles, Calif.

Handel Film Corp., 6926 Melrose Ave., Los Angeles, Calif.

International Film Bureau, Inc., 57 E. Jackson Blvd., Chicago, Ill. (Branch office in Ottawa, Ontario, Canada.)

Indiana University, Audio-Visual Center, Bloomington, Ind.

Life Magazine Filmstrip Div., Time and Life Bldg., Rockefeller Center, New York, N.Y.

McGraw-Hill Book Company, Inc., Text-Film Dept., 330 W. 42nd St., New York, N.Y.

Michigan Dept. of Conservation, Film Loan Service, Lansing, Mich.

Michigan State University, Co-operative Extension Service. Agricultural Hall, Room 10, East Lansing, Mich.

University of Minnesota, Audio-Visual Education Service, Westbrook Hall, Minneapolis, Minn.

Metropolitan Life Insurance Company, 1 Madison Ave., New York, N.Y. (Offices in San Francisco, Calif. and Ottawa, Ontario, Canada.)

Missouri Conservation Commission, Film Loan Library, Monroe Bldg., Jefferson City, Mo.

Modern Talking Picture Service, Inc., Headquarters Office, 3 E. 54th St., New York, N.Y. (Film libraries in other cities throughout the U.S., including Anchorage, Alaska, and Honolulu, Hawaii.)

University of Nebraska, Bureau of Audio-Visual Aids, Extension Div., Lincoln, Nebr.

NET Film Service, Audio-Visual Center, Indiana University, Bloomington, Indiana

The National Foundation, Public Information Dept., 800 Second Ave., New York, N.Y.

National Tuberculosis Assn., 1790 Broadwav, New York, N.Y. (Films loaned through state and local tuberculosis associations.)

State University of New York, College of Forestry at Syracuse University, Dept. of Forest Extension, Syracuse, N.Y.

Ohio Division of Wildlife, Dept. of Natural Resources, 1500 Dublin Rd., Columbus, Ohio

Oregon State System of Higher Education, Dept. of Visual Instruction, General Extension Division, 131 Coliseum, Corvallis, Ore.

Pennsylvania State University, Audio-Visual Aids Library, University Park, Pa.

Shell Oil Co., Public Relations Dept., 50 W. 50th St., New York, N.Y.

Sterling Movies U.S.A., 100 W. Monroe St., Chicago, Ill.

U.S. Forest Service, Dept. of Interior, Washington 25, D.C. (Contact film library of your state university extension division or regional office of the U.S. Forest Service.)

United World Films, Inc., 1445 Park Ave., New York, N.Y. (Branch offices in Los Angeles, Calif.; Miami, Fla.; Atlanta, Ga.; Chicago, Ill.; Portland, Ore.; Dallas, Tex.)

World Wide Pictures, P.O. Box 1055, Sherman Oaks, Calif.

## Directory of Science Materials Supply Houses

American Electronic Laboratories, Inc., 121 N. 75th St., Philadelphia, Pa.

American Hospital Supply Corp., 40–05 168th St., Flushing, Queens, N.Y.; or Evanston, Ill. (blood-typing serums, standard supplies)

American Optical Co., Buffalo, N.Y. (optical instruments)

American Type Culture Collection, 2112 M St., N.W., Washington, D.C. (bacteria)

Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N.Y. (optical instruments)

James G. Biddle Co., 1316 Arch St., Philadelphia, Pa. (scientific instruments)

Biological Research Products Co., 243 W. Root St., Stockyards Station, Chicago, Ill. (fresh and preserved mammalian specimens and organs)

Burgess Battery Co., Freeport, Ill. (dry cells)

California Biological Service, 1612 W. Glenoaks Blvd., Glendale, Calif.

California Botanical Materials Co., 861 E. Columbia Ave., Pomona, Calif.

Cambosco Scientific Co., 37 Antwerp St., Brighton, Mass.

Carolina Biological Supply Co., Elon College, N.C.

Central Scientific Co., 1700 W. Irving Park Rd., Chicago, Ill.

Chemical Rubber Co., 2310 Superior Ave., Cleveland, Ohio

Corning Glass Works, Corning, N.Y. (glassware)

Denoyer-Geppert Co., 5235 Ravenswood Ave., Chicago, Ill. (models, charts, slides, microscopes)

Difco Laboratories, Inc., 920 Henry St., Detroit 1, Michigan (reagents, culture media)

Dow Chemical Co., Midland, Mich. (chemicals)

Eastman Kodak Co., 343 State St., Rochester, N.Y. (photographic supplies and equipment)

Edmond Scientific Co., 99 E. Gloucester Pike, Barrington, N.J. (scientific instruments)

Fisher Scientific Co., Forbes Ave., Pittsburgh, Pa. (chemicals, laboratory appliances)

General Biochemicals, Inc., 677 Laboratory Park, Chagrin Falls, Ohio (chemicals)

General Biological Supply House, Inc. (Turtox), 8200 S. Hoyne Ave., Chicago, Ill.

Graf-Apsco Co., 5868 Broadway, Chicago, Ill. (microscopes)

Kimble Glass, P.O. Box 1035, Toledo, Ohio (glassware)
Lederle Laboratories, Div. of American Cyanamid Co., Middletown Rd., Pearl River, N.Y. (chemicals)
E. Leitz, Inc., 468 Park Ave., New York, N.Y. (optical instruments)
Los Angeles Biological Laboratory, Woods Hole, Mass. (living and preserved materials)
Merck & Co., Inc., 126 E. Lincoln Ave., Rahway, N.J. (chemicals)
Monsanto Chemical Co., 1700 S. Second St., St. Louis, Mo. (chemicals)
National Biological Supply Co., Inc., 230 W. Superior St., Chicago, Ill.
National Instruments Laboratories, Inc., 828 Evarts St., N.E., Washington, D.C.
New York Scientific Supply Co., Inc., 28 W. 30th St., New York, N.Y.
Nutritional Biochemicals Corp., 21010 Miles Ave., Cleveland, Ohio (chemicals)
A. J. Nystrom & Co., Inc., 3333 Elston Ave., Chicago, Ill. (charts, models)
Research Scientific Supplies, Inc., 69 W. 23rd St., New York, N.Y. (microscopes, microslides, stains)
E. H. Sargent and Co., 4647 W. Foster Ave., Chicago, Ill.
E. H. Sheldon Equipment Co., 101 Park Ave., Rm. 538, New York, N.Y. (laboratory furniture)
Spitz Laboratories, Yorklyn, Dela. (shadowboxes, plasteria)
Sprague-Dawley, Inc., P.O. Box 2071, Madison, Wisc. (laboratory rats)
Standard Scientific Supply Corp., 808 Broadway, New York, N.Y.
Testa Manufacturing Co., 418 S. Pecan St., Los Angeles, Calif. (microscopes)
Triarch Botanical Products, Ripon, Wisc. (botanical microslides)
United Scientific, Inc., 66 Needham, Newton, Mass. (optical instruments)
Wards Natural Science Establishment, Inc., P.O. Box 1712, Rochester, N.Y.
Welch Scientific Co., 1515 Sedgwick St., Chicago, Ill. (scientific apparatus)

**NOTES:**

Use this space for any additional teaching suggestions you may have.

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